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LOMA LINDA UNIVERSITY

Graduate School

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TWO ATTEMPTED INVESTIGATIONS INTO THE COMPLEXITIES  
OF STAPHYLOCOCCAL DISEASE

by

Harriet M. Sands

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A Thesis in Partial Fulfillment  
of the Requirements for the Degree  
Master of Science in the Field of Nursing

---

June 1966

113850



Each person whose signature appears below certifies that she has read this thesis and that in her opinion it is adequate, in scope and quality, as a thesis for the degree of Master of Science in Nursing.

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## PREFACE

This thesis has taken a rather unusual form after many, many hours spent on two attempted investigations regarding staphylococcal disease. For various reasons beyond my control, conclusions were inadequate in areas of pertinence.

My Research Advisory Committee has graciously allowed me to summarize my experiences and findings in an attempt to add insight into the complexities of staphylococcal infection.

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## PART I

### TWO ATTEMPTED INVESTIGATIONS INTO THE COMPLEXITIES OF STAPHYLOCOCCAL DISEASE

#### I. INTRODUCTION

Several years have gone by, but a particular picture remains focused. A middle-aged man with stooped shoulders was making his way slowly down the corridor away from a hospital room and toward the business office. His wife, a pale, emaciated and infected post-surgical patient, lay critically ill. Her extended and extensive treatment because of the infection had caused the hospital expenses to soar. Hope waned as the days slipped by and treatment continued. Comments among nurses changed from "I wonder if she will make it" to "She is going down so fast, I wonder how long she will last."

For a group of nurses having a personal interest in the patient for a long time, it would have required a very hard heart to stay "uninvolved," and gloom did settle. Aside from the tragedy of an impending and untimely death, other considerations came to mind. The patient's husband had the appearance of a laborer. How could he afford these expenses? Surely, if he had hospital insurance, it wouldn't pay for all this. He would be indebted for the rest of his life! The patient did not recover, adding a funeral expense to the husband's already heavy encumbrances.

At a time such as this for any conscientious nurse sharing in the heavy responsibility of patient care, self-evaluation must of



necessity take place. The patient could have brought the infection into the hospital at the time of admission, or it could have been institutionally acquired. If the latter, where was the breakdown in infection control? Environmental sanitation and proper isolation techniques had already been stressed. Stressed enough? The housekeeping, laboratory, and nursing departments seemed to work in close cooperation for a safe hospital environment. But safe enough? Such considerations have caused much mental agitation over the pursuing years.

Behavior of personnel would indicate that in many instances there is a lack of basic knowledge regarding constitutional and environmental factors contributing to surgical wound infection. Some specific examples are the placement of infected patients with non-infected patients, the absence of handwashing between patients, environmental uncleanness, the improper handling of soiled or contaminated dressings, and inadequate isolation and treatment techniques needed for the care of infected patients.

An additional, seemingly more serious problem encountered has been the actual possession of essential knowledge accompanied by a lack of understanding or interest for proper utilization of the knowledge. Under this category have been placed such attitudes and activities as:

1. The deliberate withholding of information of known infection from personnel in the admitting office, on the unit, and in the operating room.
2. Fear of traumatizing the patient psychologically by placing him in isolation.

3. Reluctance to increase a patient's hospital expenses required by separation and isolation procedures.

4. Lack of initiative to survey a total hospital or unit situation to arrive at a satisfactory plan for separation or isolation of an infected patient.

5. Reluctance to conform to established procedures in treating infected patients because of the additional time and effort involved.

6. Lack of insight or desire, or reluctance to increase nursing budget to add needed help when indicated to permit personnel to comply with hospital regulations related to the treatment of infected patients. Much of the dissatisfaction in placing a patient in isolation comes from the feeling that the patient will then be isolated from adequate nursing care.

It will be admitted that lack of hospital beds with overcrowding in instances, and shortages of workers have added to the confusion. However, experience has proven that when a critical bed situation arises, and an infected patient must be admitted, separated, or isolated, there are most cooperative individuals who, when approached, will discharge a patient who is convalescing to admit the acutely ill patient needing specialized care.

An extensive survey of literature was done to assist nurses in learning the general extent of, the contributing factors to, and suggested corrective measures against staphylococcal infection in clean surgical wounds. What more might be done to assist nurses to gain insight into the multiple problems connected with wound infection?



Literature revealed little information about hospital costs to patients. Perhaps an understanding of additional hospital costs to patients because of surgical wound infection, expressed in dollars and cents, would be an impressive factor in patient care. It would be worth a try! Thus a study of these costs was attempted. As will be shown later, this proved a difficult undertaking. Ensuing plans were made to study selected physical characteristics of patients with staphylococcal infections. Problems of complexity in reporting and laboratory analysis also narrowed this study. The two studies are described in the following pages.

## II. AN ATTEMPTED INVESTIGATION OF ADDITIONAL HOSPITAL EXPENSES REQUIRED AS A RESULT OF STAPHYLOCOCCAL INFECTION IN APPARENTLY CLEAN SURGICAL WOUNDS

Staphylococci are gram positive members of a group of bacteria called micrococci, and include both pathogenic and weakly or non-pathogenic strains.<sup>1</sup>

Staphylococcal disease, which varies from minor infections of the skin to fatal overwhelming septicemia,<sup>2</sup> is viewed as a problem of major concern to public health and hospital authorities.<sup>3</sup> It is universal,

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<sup>1</sup>Steadman's Medical Dictionary, 19th ed. Baltimore: The Williams and Wilkins Co., 1957, p. 1334.

<sup>2</sup>R. I. Wise, "Principles of Management of Staphylococci Infections," Journal of the American Medical Association, 166:1182, March 8, 1958.

<sup>3</sup>Environmental Aspects of Staphylococcal Disease, U. S. Department of Health, Education and Welfare, Public Health Service Publ. No. 646. Washington, D. C.: U. S. Government Printing Office, 1959, p. iii.

is generally endemic, but at times reaches epidemic proportions.<sup>4</sup> Infection of surgical wounds is not considered a new problem, and was felt to be one of the most difficult surgical problems in 1957.<sup>5</sup> During the National Conference on Institutionally Acquired Infections in September, 1963, it was brought out that "most investigators insist there has been a significant increase in institutionally acquired infections in recent years." Those with the Communicable Disease Center in Atlanta concurred with this position.<sup>6</sup>

What are the additional hospital expenses required as a result of staphylococcal infection in apparently clean surgical wounds? This aspect was pursued because of the assumption that the financial loss to patients and their families due to infection in surgical wounds is not adequately understood by nursing personnel. While extensive study has been done to identify and correct or improve environmental and constitutional factors contributing to staphylococcal infection, it was felt that a materialistic approach to the problem should also be considered by nurses to help stimulate efforts to reduce the incidence of surgical wound infections.

A perusal of literature revealed that in 1935 Meleney reported,

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<sup>4</sup>H. R. Robertson, "Symposium on Hospital Acquired Staphylococcal Infection, Part 1. The Problem of Hospital Acquired Staphylococcal Infections," Annals of Surgery, 150:768, October, 1959.

<sup>5</sup>R. Adams, "Prevention of Infections in Surgical Wounds," New England Journal of Medicine, 256:625, April 4, 1957.

<sup>6</sup>Institutionally Acquired Infections, U. S. Department of Health, Education and Welfare, Public Health Service Publ. No. 1188. Washington D. C.: U. S. Government Printing Office, 1964, p. 2.



after a five-year study, infection in clean surgical wounds required patients to be hospitalized twice as long as they would if their wounds had remained clean. No financial figures were indicated for the excess hospitalization.<sup>7</sup> In 1958 Barton referred to an investigation by Dr. W. Murray, in which he reviewed fifteen cases with surgical wound infections who used 313 hospital bed days, an average of 20.9 days.<sup>8</sup> It appeared that little work had been pursued in connection with the financial aspect of surgical wound infections, and that investigation along this line was justified.

A comparison study was attempted to show the hospital expenses incurred by two classifications of surgical patients. Fifty were to be hospitalized patients whose apparently clean surgical wounds developed staphylococci. They were to have had no major physical complication other than that for which surgery was performed, which would have increased hospital expenses. The surgical wound infection was to be identified by culture as staphylococci before the patient's discharge from the hospital. Fifty were to be hospitalized surgical patients with comparable operations, and with no other major physical complication than the problem for which surgery was performed, who recovered without incidence of infection in clean surgical wounds.

The term "wound infection" was a difficult one to define. Probably to the majority of people interested in hospital infections and

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<sup>7</sup>F. Meleney, "Infection in Clean Operative Wounds. A Nine Year Study," Surgery, Gynecology and Obstetrics, 60:273-274, February 15, 1935.

<sup>8</sup>J. Barton, "What to Do About Hospital Infections," Modern Hospital, 90:54, March, 1958.

culture reports, a wound infection means a condition in which pathogenic organisms can be cultured from wound exudate. However, because of questions regarding pathogenicity of staphylococci that continuously come into general conversation among hospital personnel, in infection control committees, and especially among nurses involved in implementing regulations set up for infection control in hospitals, it was intended that the study include apparently clean surgical wounds infected with staphylococci considered both pathogenic and weakly or non-pathogenic. A clean surgical wound was considered as one in which there is no apparent infection or contamination at the time of surgical procedure.

No attempt was made to explore the additional physicians' fees as a result of the infection, nor the loss of job hours by the patient as a result of extended hospital illness and convalescence due to surgical wound infection. Neither was effort made to find out whether the patients were carriers of staphylococci upon admission to the hospital.

Sources of information for the study were duplicate bacteriologic reports by the clinical laboratory of surgical wound exudate found positive for staphylococci, patients' medical records and financial statements.

In the beginning of plans for the study, all hospital expenses were to be included such as charges for the operating room, recovery room, anesthesiology, laboratory, x-ray, pharmacy, central supply, hospital room, special nurses required as a result of the wound infection, and miscellaneous items. It was found early in the investigation that the anesthesiologist's fee was a private physician's fee the same as that of the attending surgeon, and was eliminated from the study. Special



duty nursing, a private financial arrangement between the private duty nurse and the patient or his family, was also eliminated, and the data gathering tool was adjusted. Appendix A appeared adequate for both groups of patients.

For the purpose of a pilot study, a review was done of approximately one hundred charts of patients whose wounds cultured positive for staphylococci in 1961 and 1962 in three general hospitals in southern California. Because of the lack of a general file of patients with surgical wound infections in two of the hospitals, applicable surgical patients were identified through duplicate bacteriologic reports in the clinical laboratory which indicated that surgical wound exudate, or material obtained from the operative site at the time of surgical procedure, was found positive for staphylococci. A list of applicable patients from the third hospital was taken from the Infection Committee reports.

The requests for bacteriology, consequently the bacteriologic reports, were not always clear regarding the source of exudate. It was not clear whether the infected material had been recovered from a surgical wound or operative site, or from an acute or chronic drainage not the result of a surgical procedure. Another question was whether or not the report represented infection in a surgical wound of a currently hospitalized patient, or possibly an out-patient returning for treatment of infection in a surgical wound. When such questions arose, medical records were reviewed for clarification.

Three instances of staphylococcal infection in apparently clean surgical wounds were found which would meet the requirements set down for



the study. To find comparable surgical patients whose wounds healed without infection, it was necessary to refer to a Medical Records roster of surgical procedures performed, divided according to anatomical structure operated, and identified by case number. After the records of the infected and comparable non-infected surgical patients were found and reviewed, the financial statements from the Patient Accounts Department were tabulated.

Table I shows the hospital expenses of two sets of patients with and without staphylococcal infection in apparently clean surgical wounds, with breakdown for departmental charges.

Comparison One represented the hospital cost of a clean and infected surgical patient having unilateral direct inguinal hernia procedures. The patient with the infected wound was hospitalized 11 days with a total hospital expense of \$497.69 as compared to a six-day hospitalization and total hospital expenditure of \$282.12 for the non-infected patient.

Comparison Two represented the hospital costs of a patient whose lumbar laminectomy became infected post-surgically, and one whose comparable operative wound healed without infection. The infected patient was hospitalized 37 days and had a total hospital cost of \$1,882.10. The non-infected patient was hospitalized 10 days and had a total hospital expenditure of \$484.70.

Although the investigation involving infected patients was limited to those whose clean surgical wounds cultured positive for staphylococci before discharge from the hospital, one particular record was pursued past the first hospitalization during which a lumbar laminectomy was

TABLE I

## COMPARISON OF HOSPITAL EXPENSES OF PATIENTS WITH AND WITHOUT STAPHYLOCOCCAL INFECTION IN APPARENTLY CLEAN SURGICAL WOUNDS

Surg. Procedure: Unilateral Direct Inguinal Hernia			Lumbar Laminectomy	
Depts.	Comparison One		Comparison Two	
	Patient with Infected Wound--11 Days Hospitalization	Patient with Non-Infected Wound--6 Days Hospitalization	Patient with Infected Wound--37 Days Hospitalization	Patient with Non-Infected Wound--10 Days Hospitalization
OR, incl. Rec. Rm.	\$ 80.00	\$70.00	\$ 146.00	\$ 88.00
Lab	28.25	26.75	176.00	35.00
X-ray	--	--	105.00	45.00
Pharmacy	32.99	8.50	209.55	15.10
Central Service	29.80	8.75	81.05	16.00
Room	326.00	162.00	1,155.00	285.00
Misc.	<u>.65</u>	<u>6.12</u>	<u>9.50</u>	<u>.60</u>
Total	\$497.69	\$282.12	\$1,882.10	\$484.70



performed and the apparently clean surgical wound developed staphylococci. Table II (Comparison Three) shows differences in hospital costs between the patient with the infected surgical wound, and a patient with the comparable operative procedure whose wound remained clean. The patient with the infected wound was hospitalized for 48 days at the time of hospitalization for the original surgical procedure and development of post-surgical wound infection, with a hospital expenditure of \$2,885.05. He was hospitalized four additional times for medical and surgical treatment of the post-surgical wound infection. During the five hospitalizations, which occurred during an eight-month period, he spent 191 days in the institution at a total cost of \$11,322.32. He developed bone formation consistent with chronic osteomyelitis, experienced a narcotic addiction problem, and he deduced that he was becoming a psychiatric problem.

The comparable surgical patient without infection spent 11 days in the hospital, and had a total hospital expenditure of \$516.39. The total hospital expenditures of the infected patient were 21.93 times as great as that of the non-infected patient.

After the pilot study was completed, it was felt that although it would be difficult to find applicable cases, the study could be conducted in one general hospital by reviewing the records of surgical patients whose wounds were positive for staphylococci.

Ninety-eight medical records were reviewed for the two-year period of 1962-1963. Thirty-one were records of patients whose surgical wound or operative site cultured positive for staphylococci. Sixty-seven were records of other patients having wound exudate which cultured positive

TABLE II

COMPARISON OF HOSPITAL EXPENSES OF PATIENTS WITH AND WITHOUT STAPHYLOCOCCAL  
INFECTION IN APPARENTLY CLEAN SURGICAL WOUNDS

Comparison Three - Surgical Procedure: Lumbar Laminectomy							
Depts.	Patient with Infected Wound						Patient with Non-Infected Wound
	First Hosp. 48 Days	Second Hosp. 4 Days	Third Hosp. 22 Days	Fourth Hosp. 17 Days	Fifth Hosp. 100 Days	Sub- Totals 191 Days	Hospitalization 11 Days
OR, incl. Rec. Rm.	\$ 159.00	\$ 34.00	\$ 91.00	\$ --	\$ 63.00	\$ 347.00	\$ 69.00
Lab.	444.25	134.95	234.00	152.30	689.45	1,654.95	36.75
X-ray	87.50	20.00	20.00	15.00	185.00	327.50	45.00
Pharmacy	442.95	27.65	257.06	97.89	955.42	1,780.97	27.75
Central Service	166.30	45.70	76.40	27.70	235.10	551.20	17.75
Room	1,584.00	136.00	748.00	578.00	3,544.00	6,590.00	319.00
Misc.	<u>1.05</u>	<u>.75</u>	<u>9.05</u>	<u>22.60</u>	<u>37.25</u>	<u>70.70</u>	<u>1.14</u>
Total	\$2,885.05	\$399.05	\$1,435.51	\$893.49	\$5,709.22	\$11,322.32	\$516.39



for staphylococci. The latter group represented the records of those whose bacteriologic reports were questioned regarding source of exudate, and charts were reviewed for clarification.

When the investigation was completed, it was obvious that with the restrictions imposed, the study could not be conducted adequately because of the following findings:

1. Multiple debilitating constitutional conditions present in patients with surgical wound infections.
2. Infection, inflammation, and contaminating processes encountered in the operative site at the time of surgical procedure.
3. Mixed bacteria cultured from surgical wounds, which made it impossible to state that staphylococci were responsible for the wound infection.
4. Difficulty in finding comparable surgical patients whose wounds healed without incidence of infection.
5. Inability to separate charges incurred as a result of wound infection, or as diagnostic and treatment procedures for other constitutional factors present aside from the surgical wound infection.

Only one case of staphylococcal infection in an apparently clean surgical wound was found in the selected hospital for the two-year period 1962-1963 which met the criteria. The infection was a minimal stitch abscess which required no additional hospital expense except \$22 for a culture and sensitivity of wound exudate.

#### Summary

An investigation of hospital expenses was attempted for patients



whose apparently clean surgical wounds became infected with staphylococci, and a comparable group whose surgical wounds remained clean.

Three applicable patients found during the pilot study, whose wounds developed staphylococci, required 239 days of hospitalization at a total hospital cost of \$13,702.11. The three comparable patients whose surgical wounds remained clean required 27 days of hospitalization at a total hospital cost of \$1,283.21. However, only one case of infection in a surgical wound was found in the selected hospital during the two-year period 1962-1963 which met the criteria. The additional hospital cost for a minimal stitch abscess was \$22 for a culture and sensitivity of wound exudate.

Major findings which restricted the study were multiple constitutional problems present in the infected patients, contaminating processes found at the time of surgery, and mixed bacteria cultured from wound exudate.

### III. A REPORT OF SELECTED PHYSICAL CHARACTERISTICS OF A GROUP OF NINETY-EIGHT PATIENTS WHO DEVELOPED STAPHYLOCOCCI INFECTION

The physical picture of the ninety-eight patients reviewed for the attempted financial study made a vivid impression, far more than taking a look at any single malady which may contribute to decreased resistance to infection. It was felt that a report of the physical characteristics of this same group of patients, along with a review of study and experimentation available in literature regarding the problems of staphylococci, would assist nurses in reducing the incidence of

surgical wound infection by giving them additional insight into the following:

1. Admission and treatment of patients with staphylococci.
2. Some types of patients who may be the means of disseminating staphylococci within the hospital.
3. Need for concerted effort to protect highly susceptible patients from infections.

It was intended that all the physical characteristics presented should be chronic, recurrent, recent, or current factors which might conceivably contribute, either directly or indirectly, to the development of staphylococcal infection. As the chart study progressed, and the forms for tabulation began to take shape, it became increasingly difficult, if not impossible, to attempt to separate the constitutional factors which may or may not contribute to surgical wound infection. It was decided to divide the physical findings of the infected patients into two areas:

1. Infections and inflammations of a chronic, recurrent, recent, or current nature.
2. Other physical characteristics.

A check list (Appendix B) was designed for the collection of information pertinent to the report, and included code number, sex, age, race, dates of hospitalization, description of infection, description of surgical procedure, reports of wound cultures, and physical history.

As a result of the questions which arose from the bacteriologic reports for the attempted financial study, and clarification through chart study, three groups of patients with staphylococcal infection



became evident. To arrange the data collected for the report of the physical characteristics of the infected patients, tables were set up for each of the three groups of patients as follows:

Group 1. Surgical patients rendering staphylococci from surgical wound exudate before discharge from the hospital. Items included in the table were code number; age, sex, race; surgical procedure; infection, inflammation, perforation, gangrene, or necrosis found in the operative area at the time of surgical procedure; bacteria other than staphylococci present in the operative area either at the time of surgical procedure or in surgical wound exudate post-operatively; history of infections or inflammations; history of other physical characteristics, general comments, and total physical characteristics.

This group, as far as can be ascertained, represented all hospitalized patients whose surgical wounds cultured staphylococci before the patient's discharge from the hospital.

Group 2. Hospitalized patients requiring medical and/or surgical treatment (not duplicated above) from whose wounds staphylococci were cultured. Items included were code number; age, sex, race; description of infection, surgical procedure, bacteria other than staphylococci present in wound exudate; history of infections or inflammations; history of other physical characteristics; general comments; and total physical characteristics.

Group 3. Out-patients with staphylococcal infections who received medical and/or surgical treatment. Items included were the same as those listed for Group 2.

It was felt that it would be of interest to persons directly



concerned with infection control within the hospital to include the findings of pathogenic and non-pathogenic staphylococci, and other organisms affecting the patients treated. In order to tabulate the organisms found, it became necessary to consult with laboratory personnel regarding pathogenicity because of a variety of terms used in the reporting of staphylococci. It was found that in the early part of 1963 terminology in reporting had been changed, with the result that the reports in the two periods would not necessarily have the same connotation, making it impossible to separate pathogenic from non-pathogenic staphylococci. The change in reporting in 1963 established that Staphylococcus aureus denoted pathogenic organisms, while Staphylococcus epidermidis denoted weakly or non-pathogenic organisms. Plans were made, however, to report the total findings of other bacteria cultured from wound exudate either before, along with, or after the finding of staphylococci.

For all three groups of patients, the section on the history of infections and inflammations was broken down to include respiratory, skin, urinary, gastrointestinal, allergic reactions, osteomyelitis, and others.

Respiratory infections of a chronic, recurrent, recent, or current nature included upper respiratory infections, pneumonia, sinusitis, bronchitis, and empyema. Skin infections included pustules, furuncles, dicubiti, and draining skin cracks of a chronic, recurrent, recent, or current nature. Urinary tract infections included cystitis and pyelonephritis on a chronic, recurrent, recent, or current basis. Gastrointestinal infections or inflammations included colitis, gastric and

duodenal ulcers, diverticulitis, appendicitis, proctitis, and tephritis. Allergic reactions of a chronic, recurrent, recent, or current status involved hay fever, dermatitis, asthma, and "swelling on body for years." Osteomyelitis involved active processes.

Other infections or inflammations included such conditions as cervicitis or vaginitis, phlebitis or thrombophlebitis, infected teeth, pyorrhea, rheumatoid arthritis, bursitis or synovitis, possible flu syndrome, cholecystitis, acute draining sinus, actinomycosis, mastitis, salpingitis, labyrinthitis, peritendonitis, infectious mononucleosis, gout, Bartholin's cyst, herpes zoster, tear duct infection, hepatitis, and tuberculoma.

The section of other physical characteristics was broken down to include diabetes mellitus, cardiovascular, malignancies, emphysema, and others. Others included such conditions as osteoarthritis and degenerative hip joint disease, diverticulosis, grand mal seizures, obesity, alcoholism, anemia and malnutrition, glaucoma, collagen disease, Parkinson's disease, and paralysis due to spinal cord injury.

The classification of diabetes mellitus included both controlled and uncontrolled, and both long term and newly discovered diabetes. Cardiovascular complications grouped disorders listed as hypertensive cardiovascular disease, cerebral vascular accidents, arteriosclerosis, arteriosclerosis obliterans, coronary artery disease, coronary occlusion, and heart block. Malignancies included those of the breast, lungs, cervix, larynx, lymph, skin, prostate, and abdomen. Emphysema included minimum, moderate, and advanced stages of the disease.

Radiation and steroid therapy were listed along with the condition



for which they were administered. They were not counted as separate factors, although in retrospect they might well have been because of their deleterious effect upon the body.

Group 1. Surgical Patients Rendering Staphylococci from Surgical Wound Exudate before Discharge from the Hospital

There were thirty-one patients in Group 1. The ages of the patients ranged from 14 years to 79 years, with an average age of 48.97 years. Males comprised fourteen of the thirty-one patients, and females, 17. All patients were considered Caucasian.

Surgery performed on the thirty-one patients involved the following structures: gastrointestinal tract, 16; bone, 7; gallbladder, 2; vein (stripping), 1; female reproductive organs, 4; lungs, 2; kidney, 1; and intra-abdominal tumor, 1.

Infection or inflammation was found in the operative site of twenty-three of the thirty-one patients at the time of surgical procedure. Perforation was encountered in four patients, and gangrene or necrosis in six at the time of surgery. Staphylococci were cultured from 7 of operative sites before or at the time of surgical procedure, and 25 postoperatively.

Thirteen other bacteria were identified in Group 1 and included Enterococcus, Escherichia coli, gram negative bacilli, gram positive bacilli, gram variable spor bearing bacilli, Proteus, Pseudomonas, Streptococcus alpha, and Streptococcus gamma, Micrococcus, Aerobacter aerogenes, Welch nuttle, and indol positive atypical or paracolon. In addition, Candida albicans, a fungus, was found in one instance.



Sixty-seven infections or inflammations considered chronic, recurrent, recent, or current were identified in the charts of the thirty-one patients reviewed. There were 45 other physical characteristics identified in the group, making a total of 112 constitutional problems ranging from 1 to 7 in each patient, and an average of 3.61 for each patient.

Infections or inflammations identified were respiratory, 15; skin, 4; urinary tract, 5; gastrointestinal tract, 17, with steroid therapy in 2; allergic reactions (hay fever, dermatitis, swelling), 8; and active osteomyelitis, 1. Among the other infections or inflammations found were cervicitis and/or vaginitis, 5; phlebitis, 1; infected teeth, 1; rheumatoid arthritis with steroid therapy, 2; bursitis or synovitis, 1; possible flu syndrome, 1; cholecystitis, 2; pyorrhea, 1; acute draining sinus, 2; and actinomycosis, 1.

Other physical characteristics included diabetes mellitus, 3; cardiovascular complication, 7; malignancy, 8, with radiation in 2; emphysema, 3; osteoarthritis, 3, with steroids in 1; degenerative hip joint disease, 1; diverticulosis, 3; obesity, 11; anemia, 3; Parkinson's disease, 1; paralysis due to spinal cord injury, 1; and thyroid deficiency, 1.

Group 2. Hospitalized Patients Requiring Medical and/or Surgical Treatment (not Duplicated Above) from Whose Wounds Staphylococci Were Cultured

There were forty-seven patients in Group 2. The ages of the patients ranged from 2 weeks to 83 years, with an average age of 42.35 years. Males comprised twenty-six of the forty-seven patients, and

females, twenty-one. All patients were considered Caucasian.

Surgical procedures performed consisted of incision and drainage, with 1 surgical revision, 21; aspiration, 2; and debridement, 1.

Sixteen bacteria other than staphylococci were identified in Group 2, and included Proteus, gram positive bacilli, gram negative bacilli, Streptococcus alpha, Streptococcus beta, and Streptococcus gamma, Enterococcus, E. coli, Aerobacter aerogenes, probable Clostridium, gram positive diplococci, Neisseria gonococcus, gram negative diplococci, Pseudomonas, Micrococcus, and gram variable spore bearing bacilli. In addition, a mucor-like fungus was found in one instance.

Sixty-nine infections or inflammations were identified in the histories of the forty-seven patients reviewed. There were 64 other physical characteristics identified in the group, making a total of 133 constitutional problems ranging from zero to 10 in each patient, and making an average of 2.83 for each of the patients. The history was non-essential in four instances, and absent in one except for the current complaint of infection.

The infections or inflammations consisted of respiratory, 16; skin, 14; urinary tract, 5; gastrointestinal tract, 2; allergic reactions (hay fever, dermatitis, asthma), 9; active osteomyelitis, 5; cervicitis and/or vaginitis, 3; thrombophlebitis, 1; infected teeth, 2; rheumatoid arthritis, 1; mastitis, 2; salpingitis, 1; labyrinthitis, 1; peritendinitis, 1; infectious mononucleosis, 1; gout, 1; Bartholin's cyst, 1; herpes zoster, 1; hepatitis, 1; and tuberculoma, 1.

Other physical characteristics included diabetes mellitus, 10; cardiovascular complications, 13; malignancy, 7; emphysema, 4; osteo-



arthritis, 7; diverticulosis, 3; grand mal seizures, 1; obesity, 8; alcoholism, 1; anemia, 5; malnutrition, 2; glaucoma, 1; collagen disease with steroids, 1; and Parkinson's disease, 1.

Group 3. Out-patients with Staphylococcal Infections Who Received Medical and/or Surgical Treatment

There were twenty out-patients in Group 3. The ages of the patients ranged from 1 week to 70 years, with an average age of 36.2 years. Males comprised nine of the twenty patients, and females, eleven. All patients were considered Caucasian.

Incision and drainage of the infected area was performed in eleven of the cases, and curettement in one. Eight patients were treated without surgical intervention.

The only other bacteria cultured in this group were gram positive bacilli in one instance, and gram negative spore bearing bacilli in another.

Twenty-two infections or inflammations were identified among the twenty patients. There were 13 other physical characteristics evident in the group, making a total of 35 constitutional problems and an average of 1.75 for each patient.

The infections or inflammations identified were respiratory, 7; skin, 5; urinary tract, 3; gastrointestinal tract, 2; allergic reactions (hay fever, dermatitis, asthma), 3; herpes zoster, 1; and tear duct infection, 1.

Other physical characteristics included cardiovascular complications, 4; malignancy, 4, with radiation in 1; emphysema, 1; osteoarthritis,



tis, 1; obesity, 1; anemia, 1; and malnutrition, 1. The history was absent in three instances except for the current complaint of infection.

#### Combination of Groups 1, 2, and 3

A combination of the three groups of infected patients presented the following findings:

All ninety-eight patients included in the report were considered Caucasian. Forty-nine were males, and forty-nine females. The ages of the patients ranged from 1 week to 83 years, with an average age of 43.19 years. Fifty-four patients were 50 years of age or under, while forty-four were over 50 years. The measure of greatest frequency was a group of five patients ranging in age from 1 week to 7 months. Grouping of ages into ten-year periods appears below. Ages 61-70 included twenty-two patients, the largest number for any ten-year period.

<u>Ten-year Periods</u>		<u>Number of Patients</u>
Years	0 - 10 . . . . .	13
	11 - 20 . . . . .	7
	21 - 30 . . . . .	13
	31 - 40 . . . . .	9
	41 - 50 . . . . .	12
	51 - 60 . . . . .	12
	61 - 70 . . . . .	22
	71 - 80 . . . . .	8
	81 - 90 . . . . .	2

One hundred fifty-eight infections or inflammations which included chronic, recurrent, recent, or current processes which might conceivably contribute to the development of staphylococcal wound infection either directly or indirectly were identified among the ninety-eight patients. They included respiratory, 38; skin, 23; urinary tract, 13; gastrointestinal tract, 21, with steroid therapy in 2; allergic reactions (hay fever,

dermatitis, asthma, and swelling), 20; active osteomyelitis, 6; cervicitis and/or vaginitis, 8; phlebitis and thrombophlebitis, 2; infected teeth, 3; rheumatoid arthritis, 3, with steroid therapy in 2; bursitis or synovitis, 1; possible flu syndrome, 1; cholecystitis, 2; pyorrhea, 1; acute draining sinus, 2; actinomycosis, 1; mastitis, 2; salpingitis, 1; labrynthitis, 1; peritendonitis, 1; infectious mononucleosis, 1; gout, 1; Bartholin's cyst, 1; herpes zoster, 2; tear duct infection, 1; hepatitis, 1; and tuberculoma, 1.

One hundred twenty-two other physical characteristics included diabetes mellitus, 13; cardiovascular complications, 24; malignancy, 19, with radiation in 3; emphysema, 8; osteoarthritis, 11, with steroid therapy in 1; degenerative hip joint disease, 1; diverticulosis, 6; grand mal seizures, 1; obesity, 20; alcoholism, 1; anemia, 9; malnutrition, 3; glaucoma, 1; collagen disease with steroids, 1; Parkinson's disease, 2; paralysis due to spinal cord injury, 1; and thyroid deficiency, 1.

A total of 280 constitutional problems were found among the ninety-eight patients, ranging from zero to 10 in each patient, and making an average of 2.86 for each patient. In addition, three patients had received radiation, and six had received steroid therapy. The physical history was nonessential in four instances and absent in two except for the current complaint of infection.

Nineteen bacteria other than staphylococci were identified in the three groups and included Proteus, Enterococcus, E. coli, Pseudomonas, gram positive bacilli, gram negative bacilli, gram negative spore bearing bacilli, gram variable spore bearing bacilli, gram positive diplococci, gram negative diplococci, Streptococcus alpha, Streptococcus



beta, Streptococcus gamma, Micrococcus, Aerobacter aerogenes, Welch nuttall, Neisseria gonococcus, probable Clostridium, and indol positive atypical or paracolon. In addition, Candida albicans and a mucor-like fungus were reported.

It appeared important to point out that chronic, recurrent, recent, and current infectious and inflammatory processes totaled 158 of the 280 physical characteristics. Respiratory infections, the largest single classification, comprised 38 of the total. Hay fever, asthma, and emphysema comprised an additional 20 respiratory complications, but were not classified under respiratory infections, although intermittently infection may super-impose.

It was of interest to note that emphysema, which has the potential for harboring resistant organisms, totaled 8, which was 2 more than active osteomyelitis, a generally admitted hazard in connection with infection control in hospitals.

The second most common physical problem was cardiovascular disease which included 24, followed by 23 skin infections which did not include another seven patients with dermatitis classified as an allergic reaction.

Fewer constitutional problems were found in patients treated on an out-patient basis; an average of 1.75 for each out-patient compared to an average of 3.61 for each patient in Group 1, and an average of 2.83 for each patient in Group 2.

The most obvious difference in the findings of the three groups was a near absence of mixed bacteria cultured from wound exudate in Group 3, the out-patients.



Table III presents a comparison of the infections and inflammations identified in Groups 1, 2, and 3. Table IV presents a comparison of other physical characteristics identified in the same groups.

### Summary

These data validated the findings from previous studies as surveyed in Part II regarding staphylococcal problems in hospitals as follows:

1. Staphylococcal disease affects the very young. During the study, the measure of greatest frequency of patients with staphylococcal infection was found in infants from 1 week to 7 months of age.

2. Staphylococcal disease affects the very old. Thirty-two infected patients were found in the age bracket of 61 to 83 years, as compared to sixty-six patients ranging in age from 1 week to 60 years.

3. Staphylococcal disease affects those who are debilitated by disease, and by drug or treatment-produced complications. The identification of 280 physical complications among ninety-eight patients did validate literature in this respect. However, it was felt that graphic illustrations taken from the physical histories reviewed would help to emphasize the total figures.

One 64-year-old patient had ten physical problems: diabetes mellitus, cardiovascular disease, malignancy, duodenal ulcer, vaginitis, labyrinthitis, infected teeth, peritendonitis, diverticulosis, and glaucoma.

Another patient 64 years of age had nine physical problems: current pneumonia, recurrent skin infections, chronic cystitis, derma-

TABLE III  
COMPARISON OF INFECTIONS AND INFLAMMATIONS  
IN GROUPS 1, 2, AND 3

Infections and Inflammations	Group 1 31 Pts.	Group 2 47 Pts.	Group 3 20 Pts.	Total 98 Pts.
Respiratory	15	16	7	38
Skin	4	14	5	23
Urinary	5	5	3	13
Gastrointestinal	17	2	2	21
Steroids	(2)			(2)
Allergic Reactions				
Hay fever	3	6	1	10
Dermatitis	4	2	1	7
Swelling on body	1			1
Asthma		1	1	2
Osteomyelitis - active	1	5		6
Others				
Cervicitis and/or vaginitis	5	3		8
Phlebitis, thromphlebitis	1	1		2
Infected teeth	1	2		3
Rheumatoid arthritis	2	1		3
Steroids	(2)			(2)
Bursitis or synovitis	1			1
Possible flu syndrome	1			1
Cholecystitis	2			2
Pyorrhea	1			1
Acute draining sinus - hip	1			1
Acute draining sinus - abd.	1			1
Actinomycosis	1			1
Mastitis		2		2
Salpingitis		1		1
Labrynthitis		1		1
Peritendonitis		1		1
Infectious mononucleosis		1		1
Gout		1		1
Bartholin's cyst		1		1
Herpes zoster		1	1	2
Tear duct infection			1	1
Hepatitis		1		1
Tuberculoma		1		1
Totals	67	69	22	158



TABLE IV  
COMPARISON OF OTHER PHYSICAL CHARACTERISTICS  
IN GROUPS 1, 2, AND 3

Other Physical Characteristics	Group 1 31 Pts.	Group 2 47 Pts.	Group 3 20 Pts.	Total 98 Pts.
Diabetes mellitus	3	10		13
Cardiovascular	7	13	4	24
Malignancy	8	7	4	19
Radiation	(2)		(1)	(3)
Emphysema	3	4	1	8
Others				
Osteoarthritis	3	7	1	11
Steroids		(1)		(1)
Degenerative hip joint disease	1			1
Diverticulosis	3	3		6
Grand mal seizures		1		1
Obesity	11	8	1	20
Alcoholism		1		1
Anemia	3	5	1	9
Malnutrition or emaciation		2	1	3
Glaucoma		1		1
Collagen disease		1		1
Steroids		(1)		(1)
Parkinson's disease	1	1		2
Paralysis due spinal cord injury	1			1
Thyroid deficiency	<u>1</u>	—	—	<u>1</u>
Totals	45	64	13	122

titis, hay fever, vaginitis with ulceration, Bartholin's cyst, obesity, and collagen disease with steroid therapy.

The following variety of physical complications were found in the history of an individual 47 years of age: recurrent skin infections, draining osteomyelitis, hepatitis, diabetes mellitus, cardiovascular complications, obesity, and anemia.

Although physical complications may not appear large in numbers in any one instance, results may be devastating. One patient 44 years of age was treated surgically for proctitis with ulceration after radiation therapy for malignancy. Obesity was an additional factor.

The report of respiratory, skin, urinary, and gastrointestinal infections on a chronic, recurrent, recent, or current basis, coupled with actively draining osteomyelitis and other oozing sinuses and skin inflammations, would of necessity point to patients who may be the means of disseminating staphylococci within the hospital.

The report of numbers and types of other constitutional problems affecting the infected patients would indicate the highly susceptible patients who should be protected from infection.

#### IV. SUGGESTIONS FOR FURTHER STUDY

After considering the problems encountered while attempting the two studies, the findings from the survey of literature, and the investigator's personal experience with staphylococcal infections in hospitals, the following suggestions are made for further study:

1. Identify minimum safety techniques for adequate protection



from infection for both patients and personnel.

2. Study ways in which separation and isolation can be made more acceptable to patients and personnel.

3. Study ways of educating admitting office and unit personnel to the importance of not placing infected patients with non-infected patients, and of identifying and protecting highly susceptible patients.

4. Study ways to orient all hospital personnel to the importance of practicing medical asepsis for the protection of all patients and personnel, for example, by presenting the additional hospital cost, physical pain, and psychological trauma that may be encountered by a patient who becomes infected.

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Generally speaking, it takes a combination of factors to produce staphylococci in humans. Likewise, it requires a combination of factors, implemented through the combined efforts of all persons involved in patient care directly and indirectly, to prevent or reverse the activity. Education can erase ignorance to a great extent. But knowledge without understanding, thus without application, can be a dangerous barrier to success.

Organized effort against staphylococci is organized effort against many other organisms pathogenic to man.

## PART II

### A SURVEY OF LITERATURE

A survey of literature was done to find the general extent of, the contributing factors to, and suggested corrective measures against staphylococcal infection of apparently clean surgical wounds.

The genus Staphylococcus includes two currently recognized species, Staphylococcus aureus and Staphylococcus epidermidis. Staphylococcus aureus denotes pathogenic organisms and Staphylococcus epidermidis, weakly or non-pathogenic organisms.<sup>9</sup>

During earlier research, three species of staphylococci were recognized on the basis of colonial pigmentation: Staphylococcus aureus (golden-yellow), Staphylococcus albus (white), and Staphylococcus citreus (lemon-yellow). Although most strains isolated from human lesions produced golden-yellow pigment, and non-pathogenic strains usually were white or lemon-yellow, it was found that pathogenic colonies were sometimes white. It then became necessary to classify on a basis other than pigmentation. Coagulase production is currently considered to be the most useful means of identification of pathogenic staphylococci. Regardless of pigmentation of the colony, a coagulase positive staphylococcus is now termed Staphylococcus aureus.<sup>10</sup>

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<sup>9</sup>R. S. Breed, Bergey's Manual of Determinative Bacteriology, 7th ed. Baltimore: Williams and Wilkins Co., 1957, pp. 464-465.

<sup>10</sup>R. Dubos, ed., Bacterial and Mycotic Infections of Man, 4th ed. Philadelphia: J. B. Lippincott Co., 1965, pp. 412-413.



I. GENERAL EXTENT OF STAPHYLOCOCCAL INFECTION  
IN SURGICAL WOUNDS

Historical Findings

Boulton, writing in 1713, observed that purulence and septicemia were the common sequelae of surgery for centuries, and that if post-surgical suppuration did not appear, measures were taken to hasten "laudable pus."<sup>11</sup> Garrison, describing conditions which existed in Hotel Dieu in Paris in 1788, stated that septic fevers and other contagia were the rule, that average mortality was about 20 percent, and that recovery from surgical operations was a rarity.<sup>12</sup>

Although suggestive findings had been made as early as 1871, "in the dawning of proof of the bacterial cause of disease," the staphylococcus was not definitely associated with disease until 1880.<sup>13</sup> The pathogenicity of staphylococcus for human beings was proven between 1885 and 1887 by investigators who inoculated themselves and produced lesions from which the bacteria were recovered.<sup>14</sup> After supporting experimentation, and the introduction of additional bacteriology, Lister wrote in 1891 that "S. pyogenes aureus seems to be the most frequent cause of

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<sup>11</sup>R. Boulton, A System of Rational and Practical Chirurgery, London, 1713, as cited by R. T. Ravenholt, "Staphylococcal Infections in the Hospital and Community," American Journal of Public Health, 48: 278, March, 1958.

<sup>12</sup>F. R. Garrison, History of Medicine. Philadelphia: W. B. Saunders Co., 1917, p. 406.

<sup>13</sup>E. G. D. Murray, "About the Staphylococcus," Canadian Nurse, 55:788, September, 1959.

<sup>14</sup>Ibid.

suppuration in man."<sup>15</sup> In 1888 Lord Moynihan used to tell how, when he was a house surgeon, two out of three patients used to die after the peritoneum had been opened. Colebrook felt that "in the light of modern knowledge we cannot doubt that most of these deaths were due to infection."<sup>16</sup>

Brewer, observing in a New York City hospital in 1895, found that during a six-month period, 39 percent of all clean operative wounds became infected.<sup>17</sup> In a report of the complications in a series of 6,825 surgical operations performed in the Mayo Clinic in 1913, according to Beckman, infections determined by culture amounted to 117, or a percentage of .017. Of the positive bacteriologic cultures from surgical wounds, 96 percent contained staphylococci.<sup>18</sup>

After an estimate of approximately 2 percent wound infections, Meleney's careful records, which were started in 1925, revealed that about 15 percent of clean wounds were becoming infected in a New York hospital.<sup>19</sup> Hunt, in 1933, stated that "ten percent expresses very conservatively the morbidity from operative wound infection under average

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<sup>15</sup>Ibid.

<sup>16</sup>L. Colebrook, "Infection Acquired in Hospital," Lancet, 2:886, October 22, 1955.

<sup>17</sup>G. E. Brewer, "Studies in Aseptic Technique," Journal of the American Medical Association, 64:1369, April 24, 1915.

<sup>18</sup>E. H. Beckman, "Complications Following Surgical Operations," Surgery, Gynecology and Obstetrics, 18:552, 1914.

<sup>19</sup>Meleney, op. cit., p. 264.



standards of technique and equipment at the present time."<sup>20</sup> In 1938, Ives, of New Haven, stated that 5 percent of all clean wounds became infected in spite of preventive precautions,<sup>21</sup> and that well over 50 percent of postoperative wound infections were caused by either S. aureus or S. albus.<sup>22</sup>

### Recent Findings

In 1952 Blowers described an increase of infections to 10.9 percent in surgical chest wounds due to S. aureus sufficiently alarming to warrant closure of the chest unit for correction of the problem.<sup>23</sup> Howe reported a gradual increase of infections of clean operative wounds in Massachusetts Memorial Hospital from 1.09 percent in 1949 to 3.98 percent in 1953. Six of the 7 major wound infections in 1949 contained S. aureus, and in 1953 S. aureus was cultured from 30 of the 31 major infections.<sup>24</sup> In 1954, in the surgical ward of Malben Hospital in Beer Yaacov, Israel, Sompolinsky reported that 37 percent of all operative cases developed infection with S. aureus,<sup>25</sup> the bulk of infections being

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<sup>20</sup>E. L. Hunt, "Some Further Observations Upon Contamination of Operative Wounds by Air Borne Bacteria," New England Journal of Medicine, 209:933, November 9, 1933.

<sup>21</sup>H. R. Ives, "The Bacterial Flora of Clean Surgical Wounds," Annals of Surgery, 107:607, April, 1938.

<sup>22</sup>Ibid., p. 614.

<sup>23</sup>R. Blowers, "Control of Wound Infections in a Thoracic Surgery Unit," Lancet, 2:786, October 15, 1955.

<sup>24</sup>C. W. Howe, "Postoperative Wound Infections Due to Staphylococcus Aureus," New England Journal of Medicine, 251:414, September 9, 1954.

<sup>25</sup>D. Sompolinsky, "A Series of Postoperative Infections," Journal of Infectious Diseases, 100:2, January-February, 1957.

caused by a single staphylococcal strain.<sup>26</sup>

Of the 234 patients acquiring a staphylococcal infection in Johns Hopkins Hospital in 1959, according to Minchew, 165 persons developed 167 postoperative staphylococcal wound infections.<sup>27</sup> During a study conducted over an eighteen-month period in 1958 to 1960 at New York Hospital, Cornell Medical Center, 100 wound infections (0.87 percent) developed after 11,426 operations. S. aureus coagulase-positive was the etiologic agent in forty-seven patients, S. albus in one, enteric organisms in forty-nine cases, and streptococci in three.<sup>28</sup>

In a study of infections occurring in surgical patients over a four-year period previous to 1961 at the University of Mississippi Medical Center, there were 145 postoperative infections. S. aureus caused 83 percent of these, 72 percent by a single epidemic strain.<sup>29</sup> Culbertson, in a fourteen-month study ending February 1, 1961, found 6 infections (0.7 percent) in 817 clean operative wounds, and 17 infections (5.1 percent) in 333 clean-contaminated operative wounds. S. aureus was found in 2 of the 6 infected wounds classified as clean, and in 10 of the 17 infected wounds classified as clean-contaminated.<sup>30</sup>

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<sup>26</sup>Ibid., p. 9.

<sup>27</sup>B. H. Minchew, "Studies of the Epidemiology of Staphylococcal Infection. I. Infection in Hospitalized Patients," Journal of Chronic Diseases, 13:356, 360, 1961.

<sup>28</sup>P. Dineen, "A Critical Study of 100 Consecutive Wound Infections," Surgery, Gynecology and Obstetrics, 113:91-92, July, 1961.

<sup>29</sup>C. P. Artz, "Staphylococcal Infections: Incidence, Environmental and Laboratory Studies," Annals of Surgery, 154:572-573, October, 1961.

<sup>30</sup>W. R. Culbertson, "Studies on the Epidemiology of Postoperative



In light of the few reports reviewed, it would not be difficult to visualize that "published reports are comparable only to the visible part of an iceberg, much more remaining undisclosed."<sup>31</sup> On a well regulated surgical service, according to Howe, the rate of wound infections should not exceed 1 or 2 percent of the clean operations.<sup>32</sup>

The Seriousness of Staphylococcal Disease in the General Hospital as Revealed in Autopsy Studies

Ravenholt stated that according to reports, infection of surgical wounds in hospitals, especially with staphylococci, remains a considerable cause of death. He emphasized this by bringing out that mortality from hospital acquired pyemia and septicemia (erysipelas included) in London hospitals during the 1870's was not remarkably greater than current mortality from the same conditions in some of our large teaching hospitals.<sup>33</sup>

Evidence of the seriousness of staphylococcal disease may be seen in Boston City Hospital's 1955 study of autopsies performed. Of the 914 cases cultured for study, hemolytic S. aureus was cultivated in 266 cases as the only predominant organism from the heart's blood, spleen, lungs, or various important primary foci of infection. In an additional 198

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Infection of Clean Operative Wounds," Annals of Surgery, 154:601, October, 1961.

<sup>31</sup>Colebrook, loc. cit.

<sup>32</sup>Howe, op. cit., p. 412.

<sup>33</sup>R. T. Ravenholt, "Staphylococcal Infections in the Hospital and Community. Hospital Environment and Staphylococcal Disease," American Journal of Public Health, 48:279, March, 1958.

cases culturing either predominant non-hemolytic S. aureus or S. albus, many grew hemolytic S. aureus in small numbers either alone or mixed with other staphylococci.<sup>34</sup>

A study of the 534 autopsies performed in a university hospital in Iowa in 1956 showed that twenty patients (4 percent) were diagnosed by pathologists as having died from staphylococcal disease. In a further sixty-nine cases (14 percent), there had been severe staphylococcal disease which was considered to have contributed to death. Although staphylococci had been cultured from various areas in an additional seventy autopsies, the infections did not appear to be related to death.<sup>35</sup>

## II. CONTRIBUTING FACTORS TO STAPHYLOCOCCAL INFECTION OF SURGICAL WOUNDS

### The Unpredictability and Unknown of Staphylococci

Staphylococci are small gram positive spheres grouped in clusters, for which the human being has a high tolerance for both harmful and harmless strains.<sup>36</sup> Highly adaptable parasites, they are capable of surviving within human serum and phagocytic cells, and of adjusting to survive in

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<sup>34</sup>M. Finland, "Staphylococcal Infections Currently Encountered in a Large Municipal Hospital: Some Problems in Evaluating Antimicrobial Therapy in Such Infections," Annals New York Academy of Science, 65: 195, 197, 1956-1957.

<sup>35</sup>M. E. Godfrey, "Hospital Hazards of Staphylococcic Sepsis," Journal of the American Medical Association, 166:1199, March 8, 1958.

<sup>36</sup>L. R. Thompson, "Staphylococcus Aureus," American Journal of Nursing, 58:1098, August, 1958.



new environments including human tissue with high antibiotic content.<sup>37</sup> Some staphylococci have the ability to resist antibiotics,<sup>38</sup> and some may persist in human beings receiving chemotherapy even though the persisters may remain fully susceptible to the drug in use.<sup>39</sup> Blair commented that staphylococci are able to remain viable in the body tissue after months of dormancy.<sup>40</sup> It has been demonstrated that staphylococcal organisms survive in blankets and mattresses for months, and at room temperature for years.<sup>41</sup> The staphylococci's main asset for survival appears to be their ability to resist drying at ordinary temperatures. Increasing humidity increases the death rate of staphylococci sharply. However, at the saturation point, actual multiplication of the organisms occur.<sup>42</sup>

Some of the alterations of the staphylococci appear to be the result of mutation-like phenomena, manifest when change in environment gives a selective advantage to the mutant forms. These changes make it difficult to define a strain in terms of its pathogenic potentialities. "A culture directly recovered from an abscess may have lost temporarily some of the very properties that had first endowed it with invasive

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<sup>37</sup>Artz, op. cit., p. 573.

<sup>38</sup>Howe, op. cit., p. 416.

<sup>39</sup>R. Dubos, "The Unknown of Staphylococcal Infection," Annals of New York Academy of Sciences, 65:244, August 31, 1956.

<sup>40</sup>J. E. Blair, "What is a Staphylococcus?" Bacteriological Reviews, 26:380, 1962.

<sup>41</sup>Ravenholt, op. cit., p. 283.

<sup>42</sup>H. W. Chandler, "The Epidemiology of Surgical Infections. IV. Staphylococcus and Hospital. A Review of the Literature - Part I," Guthrie Clinic Bulletin, 32:124, October, 1962.

powers."<sup>43</sup> According to Dubos, S. aureus is strongly gram positive, but individual cells in old cultures may lose the ability to retain gram stain. In infected material, staphylococci ingested by phagocytic cells may be gram negative.<sup>44</sup>

Different strains of staphylococci behave in various ways. Chandler stated that some types produce a limited range of lesion. Some commonly colonize in the normal nose without producing septic lesions. Others common in the nose may produce sporadic septic lesions, yet rarely produce epidemics, while a few strains spread and cause sepsis.<sup>45</sup>

Injurious products of the pathogenic strains of staphylococci, according to Thompson, are necrotizing exotoxin (destroys tissue), hemolysin (destroys red blood cells) leukocidin (destroys white blood cells), and an enterotoxin which causes gastroenteritis.<sup>46</sup> According to Dubos, cultural characteristics that occur with a very high degree of frequency among the virulent strains of staphylococci are production of pigments, coagulase, hyaluronidase, leukocidin, various hemolysins, and phosphatase. None of these characteristics, however, have been "convincingly shown to play a determinant part in the ability of the staphylococci to become established in vivo or to cause disease."<sup>47</sup>

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<sup>43</sup>Dubos, op. cit., p. 245.

<sup>44</sup>Dubos, Bacterial and Mycotic Infections of Man, op. cit., p. 414.

<sup>45</sup>Chandler, op. cit., p. 126.

<sup>46</sup>Thompson, op. cit., p. 1,100.

<sup>47</sup>Dubos, "The Unknown of Staphylococcal Infection," op. cit., p. 244.



It is believed that coagulase, absent in non-pathogenic strains, plays some role in the pathogenicity, based on the staphylococci's ability to clot blood and produce disease. Blair stated that coagulase may act either to produce intravascular clotting or thrombosis, or to lay down a fibrin barrier which contributes to the development of the lesion. Coagulase appears to have a protective effect on the cocci, and is possibly more important in the early stage of development.<sup>48</sup>

Although there is no satisfactory measure of intrinsic virulence of strains of staphylococci, "much of the pathology of the stages and forms of the clinical disease is explicable in terms of the products and actions of the staphylococcus once it has invaded and grown in the patient's tissues."<sup>49</sup> S. aureus, strain 42B/52/81, has accounted for the vast majority of hospital related infections.<sup>50</sup>

Many questions arise from the seeming inconsistency of the development of clinical disease after known infection. Infection does not result from the mere presence of the cocci in the tissue, and the incidence of disease is not great considering the wide distribution of staphylococci and man's continuous exposure to them. In fact, to produce an infection experimentally in the human skin, according to Blair, or to infect a laboratory animal, requires an inoculum of around one million or more cocci. Once in the tissue, they must find a favorable

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<sup>48</sup> Blair, op. cit., pp. 376-377.

<sup>49</sup> Murray, op. cit., p. 790.

<sup>50</sup> Staphylococcal Disease, Selected Material on Nursing Aspects, U. S. Department of Health, Education and Welfare, Public Health Service. Atlanta: Communicable Disease Center, 1960, p. 8.

environment for growth and multiplication.<sup>51</sup> It is readily agreed that there are many host and parasite factors which are involved in the development of staphylococcal infection.

#### The Problem of Antibiotic Resistant Organisms

Reports indicate that penicillin resistant strains of coagulase-positive staphylococcus recovered from hospital patients have increased since penicillin was introduced in 1941. This increase has been considered to be a result of penicillin therapy.<sup>52,53</sup>

Potentially the most serious complication of the widespread use of antibiotics, according to Finland, is perhaps the emergence and increase in prevalence of organisms that are resistant to most or all of the various antibiotics used. As an example, at the Boston City Hospital during the first few years after the introduction of penicillin, 85 percent of staphylococci isolated from all sources were moderately or highly sensitive to penicillin. During the first few years after aureomycin became available, a greater proportion of staphylococci were sensitive to this agent. Since that time there has been an increase in the percentage of organisms highly resistant to the two antibiotics, so that by early 1952 only one out of four strains of staphylococci isolated could be considered sensitive to penicillin, only about two-thirds of the strains were sensitive to aureomycin, and a smaller percentage were

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<sup>51</sup>Blair, op. cit., p. 379.

<sup>52</sup>Adams, op. cit., p. 628.

<sup>53</sup>Howe, loc. cit.



sensitive to terramycin. There is progressive increase in the proportion of strains of staphylococci that are totally resistant to penicillin and are increasing in resistance to the other widely used antibiotic agents.<sup>54</sup>

From institutions in the United States and abroad come increasing numbers of reports indicating that antibiotic-resistant organisms are the cause of hospital infections.<sup>55</sup> Robertson accepted with reservation the implication that "antibiotics have brought this trouble upon us," and preferred to state that "we have not capitalized upon the antibiotics as we might have done had we used them more intelligently over the years."<sup>56</sup>

Browder wrote that much of the time prophylactic antibiotics are prescribed for vague indications,

. . . particularly to prevent bacterial complications of viral infections, to protect bed-ridden patients from developing hypostatic pneumonia, to prevent wound or pulmonary infections in patients undergoing surgery, or suffering from strokes, diabetic ketoacidosis, etc.

The beneficial effects of administering antibiotics under these circumstances have not been evident. It has been obvious, however, that often antibiotics upset the delicate balance between bacteria and the host, and result in super-infection with a resistant strain.<sup>57</sup>

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<sup>54</sup>M. Finland, "Complications Induced by Antimicrobial Agents," New England Journal of Medicine, 248:225-226, February 5, 1953.

<sup>55</sup>"A.M.A. Hears Report of Hospital Infections," Modern Hospital, 90:49, January, 1958.

<sup>56</sup>Robertson, op. cit., p. 769.

<sup>57</sup>A. A. Browder, "The Susceptible Host," Journal of Chronic Diseases, 15:729, July, 1962.

Experimentation has revealed that patients given antibiotics following surgery of the upper gastrointestinal tract and gallbladder did no better regarding fever, wound infection, and pulmonary complication than patients not receiving antibiotics. In fact, with the possible exception of colonic surgery, there is no evidence, according to Browder, that prophylactic use of antibiotics is of any value in surgical patients. Even in thoracic surgery, unless obviously infected segments of bronchial tree, lung, or pleural cavity are entered, there is doubt that antibiotics are helpful. There is general agreement in literature that antibiotics should not be employed in clean surgical cases.<sup>58</sup>

Altemeier, summing up the problem, stated that the indiscriminate use of antibiotics (unnecessary, inadequate, or ineffective antimicrobial administration) has contributed to the development of antibiotic-resistant organisms, and to a disregard for the necessity of aseptic technic and isolation. "As a result of the miraculous impact of antibiotic therapy on surgery, the development of a feeling of overconfidence and blind reliance on these agents has developed."<sup>59</sup>

Antibiotic-resistant staphylococci are secondary invaders, and cause super-infections during antibiotic therapy of infections with other organisms, according to Finland.<sup>60</sup> Thompson expressed the view

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<sup>58</sup>Ibid., pp. 729, 733.

<sup>59</sup>W. A. Altemeier, "Symposium on Hospital Acquired Staphylococcus Infections, Part III. Recommendations for Control of Epidemic Spread of Staphylococcal Infections in Surgery," Annals of Surgery, 150:777, October, 1959.

<sup>60</sup>M. Finland, "Emergence of Antibiotic-resistant Bacteria,"



that antibiotics probably do not cause staphylococci to become resistant, but by suppressing susceptible strains, and the normal bacterial flora of the area, provide opportunity for naturally resistant organisms to thrive and multiply.<sup>61</sup> Chandler stated that the resistance of staphylococci to penicillin differs from their resistance to other antibiotics. Through the production of the enzyme penicillinase, which destroys penicillin, some strains are resistant.<sup>62</sup>

A basic bacteriology text stated that a sensitive strain of S. aureus had been trained to resist 60,000 times the quantity of penicillin to which it was originally resistant, and that this highly resistant organism demonstrated a change in gram reaction from positive to negative, and an increased ability to synthesize the amino acids required for growth. It was speculated that in such a case the development of resistance to penicillin may involve changes in metabolic patterns to types unaffected by penicillin rather than ability to inactivate penicillin.<sup>63</sup>

The staphylococci's ability to resist antibiotics has resulted in lethal properties capable of causing hospital epidemics, most frequently in nurseries, maternity wards, and surgical wards, which have become so general that it has been necessary to close the entire

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New England Journal of Medicine, 253:912-913, November 24, 1955.

<sup>61</sup>Thompson, loc. cit.

<sup>62</sup>Chandler, op. cit., p. 125.

<sup>63</sup>C. Lamanna, Basic Bacteriology: Its Biological and Chemical Background, 2d ed. Baltimore: The Williams and Wilkins Co., 1959, p. 821.

hospital.<sup>64</sup>

Penicillin resistant staphylococci are about half to a third less among out-patients than among in-patients. The lower incidence among out-patients, according to Finland, is related to the amount of previous antibiotic treatment and/or hospitalization.<sup>65</sup>

In addition to the laxity in successful aseptic measures for prevention of infection previously accepted by hospital personnel as a matter of course for regular daily operations, Brown stated that antimicrobial effectiveness also reduced the extent of fundamental research on staphylococci.<sup>66</sup>

Means by Which an Individual Coming into the Hospital May Become Infected

There are four possible means by which an individual coming into the hospital may become infected, according to Robertson.

1. He may be carrying the organism with him in his nose or on his skin as he comes into the hospital, and this organism may subsequently become implanted in his wound or lower respiratory tract or elsewhere.
2. The patient may become infected as a result of his coming into direct contact with a medical attendant who is either infected or is a dangerous carrier.
3. The patient may become infected as a result of contact with another infected patient.

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<sup>64</sup>Staphylococcal Infection: A Bibliography Covering Literature of 1952 through May, 1958, U. S. National Library of Medicine Reference Division, Department of Health, Education and Welfare. Washington, D. C.: Public Health Service, June, 1958, p. i.

<sup>65</sup>Finland, op. cit., p. 913.

<sup>66</sup>J. W. Brown, "Hygiene and Education Within Hospitals to Prevent Staphylococci Infections," Journal of the American Medical Association, 166:1185, March 8, 1958.



4. The patient may become infected from contaminated surroundings even though there be no actively infected patient in the immediate vicinity.<sup>67</sup>

In a study of 189 patients with a variety of staphylococcal infections during a three-and-a-half-month period in a Seattle hospital, Wysham reported in 1957 that in 57 instances the infection was acquired before hospital admission, in 100 instances it appeared during hospitalization, and in 32 instances it appeared within sixty days after discharge from the hospital. Of the total number, 37 were infections of surgical wounds.<sup>68</sup>

In a 1959-1960 study by Glatho, cultures were taken of both nares and external vulva of 140 patients upon admission to a maternity unit. Staphylococci were present on 131 (94 percent) of the patients. Fifty-one (36 percent) were carriers of S. aureus, 80 (57 percent) carried S. albus, and 9 (7 percent) were negative for staphylococci.<sup>69</sup>

In a 1960 evaluation by Darling of preoperative skin preparation procedures, cultures of the operative area of 100 surgical patients were taken upon admission to the hospital to determine what types of organisms they had on entering the hospital. Operative sites excluded in the study were those of the perineum and scalp, or an infected field. Although 91 of the patients entered the hospital with gram

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<sup>67</sup>Robertson, op. cit., p. 770.

<sup>68</sup>D. N. Wysham, "Micrococcic (Staphylococcic) Infections in a General Hospital," Journal of the American Medical Association, 164: 1739, August 17, 1957.

<sup>69</sup>C. L. Glatho, "The Presence of Staphylococcus Aureus on Mothers Admitted to a Selected Maternity Unit," Unpublished Master's Thesis, Loma Linda University, Loma Linda, California, June, 1960, p. 23.

positive cocci, none of the organisms were identified as S. aureus. Postoperatively, 3 patients developed wound infections.<sup>70</sup>

A study conducted at the University of Mississippi Medical Center revealed that staphylococcus coagulase-positive was present on 44 percent of the medical and surgical patients on admission.<sup>71</sup>

Patients and personnel. Jawetz felt that the heaviest contribution to the total number of staphylococci in the hospital is made up by infected patients themselves, who spread resistant forms of the organism in the environment. Among patients admitted to the hospital for treatment of staphylococcal disease are found those with bedsores, mastitis, upper respiratory infections, pneumonia, extensive skin furuncles, draining osteomyelitis, and extensive eczema. There are increasing numbers of patients with fibrocytic disease of the lung, emphysema, and bronchitis, who require repeated hospital admission and who, by the nature and management of their disease, frequently are carriers of resistant staphylococci.<sup>72</sup>

In a January, 1956, spot survey in Boston City Hospital of 1172 patients, 68 had staphylococcal infections present at the time of admission, and 113 had staphylococcal infections which were probably acquired in the hospital. Table V illustrates the findings in both

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<sup>70</sup>M. Darling, "An Evaluation of Two Preoperative Skin Preparation Procedures Used in the Operating Room of a Selected Hospital," Unpublished Master's Thesis, Loma Linda University, Loma Linda, California, June, 1960, pp. 4, 37, 38.

<sup>71</sup>Artz, op. cit., p. 583.

<sup>72</sup>Environmental Aspects of Staphylococcal Disease, op. cit., p. 240.



TABLE V

SPOT SURVEY OF STAPHYLOCOCCAL INFECTIONS  
BOSTON CITY HOSPITAL, JANUARY, 1956\*

Number of Patients Surveyed . . . . .		1172
1. Infections Present at Time of Admission (68)		
Serious Infections (15)		Less Serious Infections (53)
Osteomyelitis . . . . .	6	Infected burns, rashes,
Sinusitis and cellulitis . . . . .	3	ulcers, and wounds . . . . .
Endocarditis . . . . .	2	Furuncles, felons, carbuncles . . . . .
Pneumonia and/or empyema . . . . .	2	Breast abscesses . . . . .
Carbuncle with bacteremia . . . . .	1	Chronic suppurative otitis . . . . .
Peritonitis . . . . .	1	Urinary tract infection . . . . .
2. Infections Probably Acquired in the Hospital (113)		
Serious Infections (16)		Less Serious Infections (97)
Pneumonia and empyema . . . . .	6	Burns, wounds, ulcers . . . . .
Burns, wounds, ulcers . . . . .	3	Furuncles, abscesses . . . . .
Bacteremia, ? source . . . . .	2	Respiratory tract . . . . .
Carbuncles, soft-tissue		Urinary tract . . . . .
infect . . . . .	2	
Meningitis, postop . . . . .	1	
Subphrenic abscess, postop . . . . .	1	
Infected "cutdown" +		
bacteremia . . . . .	1	

\*M. Finland, "Staphylococcal Infections Currently Encountered in a Large Municipal Hospital: Some Problems in Evaluating Antimicrobial Therapy in Such Infections," Annals New York Academy of Sciences, 65: 192, 1956-1957.

groups.<sup>73</sup>

Colebrook attributed the origin of many infections to organisms expelled from the nose and throat of individuals suffering from upper respiratory infections. Posing a difficult problem in the control of cross infection of wounds is the fact that both patients and personnel harbor in their noses and throats staphylococci resistant to antibiotics without manifest signs of infection.<sup>74</sup>

Ravenholt indicated that contamination by nasal carriers was accomplished especially by their transferring organisms with their hands to their clothing, from which staphylococcal-laden particles liberate into the air by movement of the clothing.<sup>75</sup>

Howe reported that the nose and naso-pharynx are the chief reservoirs of virulent staphylococci.<sup>76</sup> Sanford expressed the opinion, in the light of epidemiological evidence, that personnel who carry virulent strains may be the major reservoir from which staphylococcus is disseminated.<sup>77</sup> Sompolinsky reported that after careful investigation, two operating room nurses who were carriers were apparently responsible for postoperative wound incidence of 37 percent, caused by S. aureus, by

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<sup>73</sup>M. Finland, "Staphylococcal Infections Currently Encountered in a Large Municipal Hospital: Some Problems in Evaluating Antimicrobial Therapy in Such Infections," op. cit., p. 192.

<sup>74</sup>Colebrook, op. cit., pp. 887-888.

<sup>75</sup>Ravenholt, op. cit., p. 282.

<sup>76</sup>Howe, op. cit., p. 412.

<sup>77</sup>J. P. Sanford, "A Successful Staphylococcal Control Program Which Failed," Journal of Laboratory and Clinical Medicine, 59:597, April, 1962.



lowering their masks and conversing in the operating room during surgery.<sup>78</sup> Artz found that in hospital personnel, 53 percent were carriers of coagulase-positive staphylococci in their nose or throat, and that 40 percent of the 1,640 members of the community harbored coagulase-positive staphylococci in their nose and throat.<sup>79</sup>

According to Kedjia, qualitative investigations of the biochemical properties of virulent and avirulent staphylococci have shown that almost all cultures recovered from suppurative lesions of the skin yield more positive reactions than strains recovered from other sources.<sup>80</sup> Jawetz also stated that staphylococci which come directly from a lesion are likely to be greater both in number and virulence than those from an asymptomatic carrier.<sup>81</sup>

In a January, 1956, survey of staphylococcal infections among the house staff at Boston City Hospital, eighteen members had large furuncles or carbuncles, some of which involved only unexposed parts. Six of the eighteen were on general surgical services, seven on medical services. Two were orthopedic surgeons, two were pathologists, and one was an anesthesiologist. At least nine others of the resident staff had recently recovered from staphylococcal infections. In most instances the house surgeons and physicians had been hospitalized at

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<sup>78</sup>Sompolinsky, op. cit., pp. 8, 9.

<sup>79</sup>Artz, loc. cit.

<sup>80</sup>W. Kedjia, "The Phosphatase Activity of Coagulase Positive Staphylococcus Aureus Strains Isolated from Patients and Healthy Persons," Journal of Pathology and Bacteriology, 85:528, 1963.

<sup>81</sup>Environmental Aspects of Staphylococcal Disease, loc. cit.

least part of the time for these infections, and were excluded from operating for long periods because of the infections.<sup>82</sup>

A less thorough inquiry at the same institution about nursing personnel revealed that seven nurses were absent from duty because of staphylococcal infections, that five of the seven were hospitalized at the time for the infections, that nine others had recently been treated for staphylococcal skin infections, and that there were also at least eight ward attendants who were recently treated, or were being treated, for significant infection of the skin of exposed surfaces.<sup>83</sup>

The number of hospital personnel colonized has been reported to range between 10 and 80 percent in different studies, while the length of time employed in the hospital appears to increase the number of personnel who acquire the infection.<sup>84</sup>

Environment. Pathogenic organisms disseminated from patients and personnel can enter the air in droplet spray produced by speaking, coughing, or sneezing, and in active particles as a result of friction and movement from the skin and clothing of infected persons. These may be harbored on the floor, walls, furniture, bedding, instruments, and utensils. They may be circulated by such activities as sweeping, making a bed, dusting, shaking linen, natural and forced ventilation, vacuum cleaners, mops, etc. Airborne infection through contaminated dust is

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<sup>82</sup>Finland, op. cit., pp. 193-194.

<sup>83</sup>Ibid.

<sup>84</sup>Brown, op. cit., p. 1187.



clearly one mode of spread of staphylococci.<sup>85,86,87</sup>

Blowers found that the accumulation and distribution of pathogenic organisms on blankets and sheets contributed to infection of wounds and burns. He regarded bedclothes as part of the patient's wound dressing, and felt that they should be free from pathogenic organisms.<sup>88</sup> Ravenholt confirmed that hospital blankets, sometimes circulated from patient to patient, yielded pathogenic organisms; in his study, antibiotic-resistant strains of S. aureus.<sup>89</sup> Various methods for testing show that organisms are scattered far and wide whenever bedding is disturbed.<sup>90</sup>

Adams stated that mattresses are rarely thought of as a source of contamination. He classified the mattress as the modern equivalent of the wall hung pin cushion which was used in surgery in the pre-antiseptic era for holding needles between cases. He emphasized that the greatest statistical source of mattress contamination, and hence of spread of infection from patient to patient, is the sweat, urine, and body secretions from the "average" patient which "leave a heritage of

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<sup>85</sup>J. P. Duguid, "Air Infection with Dust Liberated from Clothing," Lancet, 2:845, November 27, 1948.

<sup>86</sup>J. C. Sherris, "Physical and Chemical Means of Infection Control," Journal of Chronic Diseases, 15:743, July, 1962.

<sup>87</sup>A. D. Langmuir, "Ecologic and Epidemiologic Aspects of Staphylococci Infections in Hospitals," Journal of the American Medical Association, 166:1202-1203, March, 1958.

<sup>88</sup>R. Blowers, "Clean Beds," Lancet, 1:629-630, March 23, 1957.

<sup>89</sup>Environmental Aspects of Staphylococcal Disease, op. cit., pp. 157-158.

<sup>90</sup>Blowers, op. cit., p. 629.

staphylococcal growth on mattresses no different from that to be found on used linen which is usually autoclaved before re-use. But tradition does not require any special attention to such ordinarily used mattresses."<sup>91</sup>

Hurst concluded that laundry and refuse chutes were a source of coagulase-positive, penicillin-resistant staphylococci, and that strong updrafts returned these staphylococci to the hospital corridors whenever the chute doors were opened.<sup>92</sup> This activity may also be applied to drafts caused by elevators. The cloud of dust and bacteria caused by the emptying of waste from one container to another contributes to airborne and contact infection.<sup>93</sup>

The hospital laundry can be an important factor in the spread of infection<sup>94</sup> as pertains to place and method of storage, sorting, and handling of dirty and contaminated linen, and methods of washing, handling, storage, and transfer of clean linen. Brown observed that the same carts are often used to transport both clean and dirty linen, often uncovered, through hospital corridors and past many people.<sup>95</sup>

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<sup>91</sup>R. Adams, "Prevention of Infection in Hospitals, American Journal of Nursing, 58:345, March, 1958.

<sup>92</sup>V. Hurst, "Hospital Laundry and Refuse Chutes as Source of Staphylococci Cross Infection," Journal of the American Medical Association, 167:123, 128, July 5, 1958.

<sup>93</sup>Environmental Aspects of Staphylococcal Disease, op. cit., p. 53.

<sup>94</sup>H. I. Harder, "Staphylococcal Infections," American Journal of Nursing, 58:351, March, 1958.

<sup>95</sup>Brown, loc. cit.



The gauze mask can be a potential hazard if worn incorrectly, casually, or over a prolonged period. Another hazard is undue confidence placed in protection afforded by the mask. If masks are worn over a prolonged period, the number of organisms disseminated are greatly increased. Emphasis was given to the fact that the removal and dangling of a mask that is wet and growing staphylococci, for the purpose of drying and replacing it over the face, provides greater dissemination.<sup>96</sup>

Investigations of means of cross infection have been conducted in minute detail. Some of the factors responsible have been such articles as common ink pad for footprinting at birth, common ointments, common combs and hairbrushes, and common thermometers.<sup>97</sup> Added to the list may be common containers for lubricants, stethoscopes, sphygmomanometers, etc. Other areas of concern in the prevention of staphylococcal spread are anesthetic masks, tubing and bags, water humidifiers, drinking water containers at the bedside, and soap and soap dishes.<sup>98</sup>

Excreta. The part that infected feces and urine may play in the spread of staphylococci has been approached in literature. Authors have suggested that S. aureus may reach the feces through nasal carriers swallowing the organisms, and may be a means of dissemination of staph-

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<sup>96</sup>Ibid.

<sup>97</sup>Ibid.

<sup>98</sup>Sherris, op. cit., pp. 751-752.

ylcocci in the hospital.<sup>99</sup> In July, 1960, the number of S. aureus isolations from stool specimens sent to the bacteriology laboratory of Johns Hopkins Hospital markedly increased. These positive reports represented an increase in incidence of S. aureus in the stool, not merely a greater number of stools sent to the laboratory for examination.<sup>100</sup>

In a study of 243 consecutive, hospitalized patients who had S. aureus in the intestine, it was revealed that symptoms produced by the organism may vary from mild to severe, and that the same type of S. aureus can exist in the intestine and in other sites of the body at the same time. Staphylococcal enteritis was more likely to occur among postoperative patients receiving antibiotics capable of altering the intestinal bacteria.<sup>101</sup>

Adams stated that the "problem of cross infection on the ward has become so serious that a simple procedure like bladder catheterization must now be regarded as having potentially dangerous consequences." It was his opinion that catheterization will inevitably be followed by infection, either active or latent. Studies have shown that the infection may be found years later in active or latent form.<sup>102</sup>

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<sup>99</sup>R. Hare, "The Transmission of Staphylococcus Aureus," British Medical Journal, 2:841, October 13, 1956.

<sup>100</sup>L. S. Cohen, "A Study of the Intestinal Flora in a Closed Pediatric Community," American Journal of Hygiene, 76:262, 1962.

<sup>101</sup>W. H. Dearing, "Hospitalized Patients with Staphylococcus Aureus in the Intestine," Journal of the American Medical Association, 174:1597, 1960.

<sup>102</sup>Adams, op. cit., p. 347.



Gram negative bacilli account for approximately 80 to 90 percent of all urinary infections while S. aureus, Streptococcus fecalis, and tubercle bacilli account for the remaining 10 to 20 percent.<sup>103</sup>

It would seem feasible to consider that feces and urine may be a means of disseminating staphylococci by contaminating skin and mucous membranes, bedding, bedpans, urinals, and bathroom facilities.

Shifting of personnel. The spread of hospital infection has also been attributed to the shifting of nursing personnel from one department to another during shortages of help rather than remaining in the one area to which they were assigned.<sup>104</sup> Results have been that workers assigned to such areas as nursery, labor and delivery, and operating room have been transferred to areas of known staphylococcal infection, then back to their own departments where inevitably the organisms would be transmitted.

Modification of host resistance. McDermott felt that in the problem of infection, it is not so much that patients in hospitals are now being subjected to any greater exposure by staphylococci, but that people are less well equipped to meet the "same old challenge." He gave as contributing factors modern therapies which are permitting the survival of those who are less able to resist the infection, and

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<sup>102</sup>Adams, op. cit., p. 347.

<sup>103</sup>D. Santora, "Preventing Hospital-Acquired Urinary Infections," American Journal of Nursing, 66:791-792, April, 1966.

<sup>104</sup>Barton, op. cit., p. 51.

commonly used diagnostic and treatment procedures which facilitate the development of infections.<sup>105</sup>

Patients particularly susceptible to infection with hospital staphylococci are premature and newborn infants, the very aged, post-operative patients, uncontrolled diabetics, patients with diminished vital capacity, patients after severe viral infections, those receiving steroids, those whose own bacterial flora has been altered by antibiotic administration, patients who lack specific mechanisms of resistance as in leukemia and agranulocytosis, those with breaks in the skin,<sup>106</sup> patients with cancer,<sup>107</sup> and those who have had irradiation therapy.<sup>108</sup>

Blair added that circumstances favorable to the cocci are contributed by local conditions in the tissue where they lodge. Examples given were devitalized tissue such as on a burn area, local pressure or friction which interfere with physiological function, and foreign bodies. He also emphasized the state of nutrition as an important factor in host resistance.<sup>109</sup>

"As operative procedures increase in magnitude, and as older poor risk patients are subjected to surgery, host resistance in such patients

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<sup>105</sup>W. McDermott, "The Problem of Staphylococcal Infection," British Medical Journal, 2:839-840, October 13, 1956.

<sup>106</sup>Environmental Aspects of Staphylococcal Disease, op. cit., p. 242.

<sup>107</sup>D. R. Boggs and E. Frie, III, "Clinical Studies of Fever and Infection in Cancer," Cancer, 13:1250-1251, 1960.

<sup>108</sup>McDermott, loc. cit.

<sup>109</sup>Blair, op. cit., p. 380.



diminishes, and there is more fertile field for the development of staphylococcal infections."<sup>110</sup> According to Price, "It is one of the true medical ironies that the staphylococcus organism, long a relatively innocuous resident of our environment, has turned dangerous as an indirect result of our greatest scientific achievements."<sup>111</sup>

Probability that all surgical wounds are inoculated with bacteria at operation. It is probable that all surgical wounds are inoculated with bacteria at operation. According to Howe, whether or not sepsis develops depends upon the capacity of the organism, the resistance of the host, the size of the inoculum, the degree of excellence in surgical or antiseptic technique, the presence of physiological derangements, the type of tissue involved, climatic or seasonal variations in bacterial flora, and dissemination of drug-resistant bacteria.<sup>112</sup>

Ives demonstrated that the skin is not sterile at the beginning of an operation, and is very heavily contaminated at the close of a surgical procedure. Among thirty patients studied, positive cultures were obtained from the skin after the skin preparation and draping, and before the operation, in 86 percent of the cases, and in 100 percent at the close of the operation. Of the thirty cases, six (20 percent) of plates cultured were positive for staphylococci at onset of the operation, while twenty-two (73 percent) were positive at the close. Among

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<sup>110</sup>Artz, op. cit., p. 573.

<sup>111</sup>Institutionally Acquired Infections, op. cit., p. 152.

<sup>112</sup>Howe, op. cit., p. 411.

the 44.4 percent positive cultures from the fascia at the start, 38 percent were positive for staphylococci. Of the 82 percent positive cultures of the fascia at the close of surgery, 76 percent were positive for staphylococci. In these thirty surgical wounds showing positive cultures at the time of operation, infection developed in only one (S. albus).<sup>113</sup>

McDermott stated that considering the wide distribution of the staphylococcus, its clinical manifestation and spread among a group of persons are not to be regarded as visitation from without, but an indication that something is going wrong with the crude equilibrium which previously existed, permitting the cocci to gain control.<sup>114</sup> Elek came to the conclusion that the puzzling feature of staphylococcal wound infection is not why it arises, but why it does not occur more often.<sup>115</sup>

### III. SUGGESTED CORRECTIVE MEASURES AGAINST STAPHYLOCOCCAL INFECTION OF CLEAN SURGICAL WOUNDS

While Brown reported that the consensus suggested the newborn nursery as being the most important reservoir of the "epidemic type" of staphylococci in hospitals,<sup>116</sup> it appeared to Adams that the Number One source of wound infection is the atmosphere over an open wound contami-

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<sup>113</sup>Ives, op. cit., p. 610

<sup>114</sup>McDermott, op. cit., p. 837.

<sup>115</sup>S. D. Elek, "The Virulence of Staphylococcal Pyogens for Man. A Study of the Problems of Wound Infection," British Journal of Experimental Pathology, 38:584, December, 1957.

<sup>116</sup>Brown, loc. cit.



nated by organisms escaping from exhalation droplets of personnel.<sup>117</sup>

Studies have confirmed, according to Adams, that most of the contamination of the operating room air comes directly from the operating room personnel. He also brought out that turbulence of floor dust in a well cleaned and ventilated operating room is of demonstrable but minor significance in causation of air contamination in the absence of personnel.<sup>118</sup>

Harder's investigation of S. aureus in the operating suite revealed that each time S. aureus was discovered on blood agar plates placed in the operating room, an explanation could usually be found. She cited four instances in which patients apparently brought the organisms to the operating room without previous knowledge by the operating room personnel of the infections and subsequent precautionary preparation. One patient had been showing numerous staphylococcal colonies in her stools previous to surgery. One patient who had a bronchoscopy also had S. aureus pneumonia. Another patient, from whose dicubitus ulcer S. aureus was cultured, had cystoscopy. The other patient had an incision and drainage of the hand with known S. aureus infection.<sup>119</sup>

Over eighty years ago Billroth felt that infection had its origin in the operating room. He experimented by painting the freshly wounded abdominal wall of rabbits with highly virulent staphylococci, after

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<sup>117</sup>Adams, op. cit., p. 344.

<sup>118</sup>Adams, "Prevention of Infections in Surgical Wounds," op. cit., pp. 625, 627.

<sup>119</sup>Harder, op. cit., pp. 349-350.

which the animals died rapidly. In another group he waited twenty-four hours after inflicting the wounds, then painted the wounds with staphylococci, and all these animals survived. As a result Billroth maintained that a fresh wound would infect, while a healing wound would not. Beck conceded that if the contention were true, all efforts must be bent to eliminate bacterial contamination of surgical wounds in the operating room.<sup>120</sup>

The following suggestions for the prevention of wound infection consist of a combination of pertinent findings and beliefs as presented in medical, hospital, and nursing literature. The most rigid methods of control appeared to be established in the operating room.

#### Awareness and Responsibility

The most important aspect in preventing wound infection appeared to be an awareness on the part of the entire hospital staff of the nature, magnitude, and epidemiology of staphylococci,<sup>121</sup> with continued educational programs at all levels and in all phases of the problem.<sup>122</sup> To lead out, it was suggested that a Committee on Infections should be established in each hospital to study the infection problem, and reduce the incidence to the lowest possible minimum. Recommendation was made that the Infection Committee should include, where possible, a bacteri-

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<sup>120</sup>W. C. Beck, "The Secondary Responsibilities of the Surgeon," Guthrie Clinic Bulletin, 32:139, January-April, 1963.

<sup>121</sup>Howe, op. cit., p. 416.

<sup>122</sup>W. R. Sandusky, "Symposium on Hospital Acquired Staphylococcus Infections, Part II. A Report on the National Conference on Hospital Acquired Staphylococcal Disease," Annals of Surgery, 150:773, October, 1959.



ologist, pediatrician, surgeon, internist, nurse, and the hospital administrator.<sup>123</sup>

With the development of methods to identify and combat hospital infections, areas of responsibility should be clearly understood, and rigid inspection should be required to insure that standards are being maintained. Kilpatrick felt that one of the greatest weaknesses in a sanitation program is the lack of definition of areas of responsibility, with a breakdown in program effectiveness.<sup>124</sup> Of importance in infection control are an adequate bacteriological service for identifying and tracing the origin of infections for causative factors, and accurate records of infections for a basis for study and recommendations regarding remedial measures.<sup>125</sup>

### Personnel

The literature contains many different statements about the proper place of the hospital worker who is a carrier, or who has an active upper respiratory infection or staphylococcal lesion. According to the American Hospital Association recommendations on the hospital infection problem in 1958, transfer of carriers and personnel with skin infections, boils, and acute upper respiratory infection from locations such as operating rooms, delivery rooms, food handling positions, and

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<sup>123</sup>"AHA's Recommendations on Prevention and Control of Staphylococcus Infections in Hospitals," American Journal of Nursing, 58:1099, August, 1958.

<sup>124</sup>Environmental Aspects of Staphylococcal Disease, op. cit., pp. 171, 172.

<sup>125</sup>"AHA's Recommendations on Prevention and Control of Staphylococcus Infections in Hospitals," loc. cit.

nurseries to other duty stations in the hospital was considered usually sufficient to control the problem.<sup>126</sup>

In 1959 Altemeier recommended that all personnel with established staphylococcal infections be excluded from the operating room, nursery, laundry, and areas of contact with patients. He suggested control and treatment of carriers shown to harbor the same epidemic strains of staphylococci as those found in local hospital infections. He also stated that present evidence indicated that coagulase-positive staphylococcal carriers need not be excluded from the operating pavilion as long as adequate masking and aseptic precautions are taken.<sup>127</sup> In 1963, in a repetition of control methods for hospital staphylococcal infections, he stated that all personnel with established, staphylococcal infection should be excluded from the operating room, recovery room, and intensive care areas.<sup>128</sup>

In 1958 Modern Hospital contained an article on hospital infections which stated, "Do not permit members of staff with upper respiratory infections and staphylococcal lesions to work."<sup>129</sup> In January, 1958, reports to the American Medical Association on hospital infections indicated that for control, hospital personnel with cutaneous staphylococcal infections were restricted from duty as soon as the infections

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<sup>126</sup>Ibid.

<sup>127</sup>Altemeier, op. cit., p. 775.

<sup>128</sup>W. A. Altemeier, "Prevention and Control of Infections in Hospitals," Hospitals, 37:65, May 16, 1963.

<sup>129</sup>"Medical Authorities Recommend Ways to Curb Infections," Modern Hospital, 90:53, March, 1958.



were identified, and were not allowed to return to duty until all drainage ceased and there was no evidence of additional infection.<sup>130</sup>

Beck commented that there are differences of opinion as to whether or not the carrier is an important factor in operating room infection. He stated that the carrier has been subjected to certain indignities and has been denied access to the operating room, while the surgeon is not so managed, nor even treated for the carrier state to his knowledge. The procedure of control apparently has been limited to "lesser individuals who actually do not have as intimate contact with the operative wound as the surgeon."<sup>131</sup>

Several suggestions were given by Artz in the management of nasal carriers. He felt that a known nasal carrier of coagulase-positive staphylococci who is not experiencing recurrent skin infections, and to whom no case of infection can be specifically traced is a benign carrier who needs no special attention other than periodic nasal cultures. A nasal carrier who has recurrent skin infections should not be permitted patient contact when skin infection is present, and should receive autogenous vaccine therapy and intranasal antibiotic ointment. For a known nasal carrier undergoing an elective operation, he suggested that the patient should use local antibiotic treatment to the nares for a period of seven days before being subjected to the procedure. For the surgeon who is a known nasal carrier of staphylococci, the use of topical antibiotics intranasally can keep the nasal count to a minimum and

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<sup>130</sup>"A.M.A. Hears Report of Hospital Infections," op. cit., p. 50.

<sup>131</sup>Beck, op. cit., p. 141.

sometimes eliminate the microorganisms.<sup>132</sup>

In case of epidemic situations accompanied by repeated cases traceable to the same organism, it was recommended that special studies be done to uncover silent carriers of the strain associated with the outbreak.<sup>133</sup> Suggestion was also made that to help regulate the problem of permanent carriers, anterior nasal cultures of members of the operating room staff should be done at intervals.<sup>134</sup>

There is current hope that the unsolved problem of medical personnel who are carriers of staphylococci in their noses and throats may soon be resolved. A potent enzyme, lyostaphin, in its first clinical test on humans, destroyed the dangerous staphylococci in the noses and throats of nurses and medical students by tearing apart their protective coating of protein. This attempt was apparently the first realization of dreams of a "magic bullet that would attack one and only one type of germ with deadly efficiency."<sup>135</sup>

#### Operating Room Activities

Strict aseptic technique. Strict aseptic technique should be established and maintained in the operating room.<sup>136</sup> Beck commented

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<sup>132</sup>Artz, op. cit., pp. 581-582.

<sup>133</sup>"AHA's Recommendations on Prevention and Control of Staphylococcus Infections in Hospitals," loc. cit.

<sup>134</sup>"Medical Authorities Recommend Ways to Curb Infections," loc. cit.

<sup>135</sup>"Enzyme Kills Staph Germs," The Kansas City Times, Kansas City, February 3, 1966.

<sup>136</sup>Altemeier, "Symposium on Hospital Acquired Staphylococcal Infections, Part III. Recommendations for Control of Epidemic Spread of Staphylococcal Infections in Surgery," op. cit., p. 774.



further in this regard:

The aseptic chain is as strong as its weakest link. Probably the best observer of breaks in technique is the circulating nurse or the scrub nurse. Yet her comments are, at times, the fuse which ignites the surgeon's adrenal flame. As a result she may well be sufficiently cowed so that she will not report the hole in the glove, or the contaminated instrument, although she fights with her conscience in withholding such comment.<sup>137</sup>

Two other obvious breaks in technique were listed as the wetting of the surgical gown, and wetting of the drapes.<sup>138</sup>

Operating room clothing. No one should enter the operating suite without removing street clothes and re-dressing with operating suit or gown, cap, mask, and shoes,<sup>139</sup> nor should surgery attire be worn outside the operating suite.<sup>140</sup> The mask, preferably one with absorbent filters, should cover both nose and mouth, and should be changed hourly during the time a wound is open.<sup>141</sup> It was recommended that the cap, as well as the mask, should be changed between cases.<sup>142</sup> Cover shoes of muslin were recommended to be worn in the operating suite.<sup>143</sup> Felt to be of benefit also was the disinfectant bath in which to clean the soles of shoes before a person enters the operating

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<sup>137</sup>Beck, op. cit., p. 142.

<sup>138</sup>Ibid.

<sup>139</sup>Altemeier, loc. cit.

<sup>140</sup>"A.M.A. Hears Report of Hospital Infections," loc. cit.

<sup>141</sup>Adams, "Prevention of Infections in Hospitals," loc. cit.

<sup>142</sup>"A.M.A. Hears Report of Hospital Infections," loc. cit.

<sup>143</sup>"Medical Authorities Recommend Ways to Curb Infections," loc. cit.

suite.<sup>144</sup> It was emphasized that every member of the entire crew which works in an operating room should bathe daily, and dress in clean clothes daily.<sup>145</sup>

Minimize equipment and movements in operating room. All unnecessary equipment, and entries to and from the operating room should be eliminated. The opening and closing of doors, and movements of operating room personnel should be minimized. Transfer of patients to the surgery table should be done gently and with a minimum of movement. The transfer, if possible, should take place in the anesthesia room. The patient's bed and bedding should not enter the operating room.<sup>146,147</sup>

All unnecessary persons should be excluded from the operating room, including visitors and personnel inadequately trained in aseptic technique.<sup>148</sup> All movements in the operating room should be purposeful.

Skin preparation of the operative area. There are many variations in literature regarding solutions used for skin preparation of the operative area and the time element involved. The most generally accepted idea appeared to be that among the methods tried, nothing has been found to equal in effectiveness as earnestly and enthusiastically applied

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<sup>144</sup>"A.M.A. Hears Report of Hospital Infections," loc. cit.

<sup>145</sup>Beck, op. cit., p. 141.

<sup>146</sup>"Medical Authorities Recommend Ways to Curb Infections," loc. cit.

<sup>147</sup>M. N. Levin, "Staphylococcal Hospital Infections," New England Journal of Medicine, 256:157, January 24, 1957.

<sup>148</sup>Altemeier, "Prevention and Control of Infections in Hospitals," loc. cit.



mechanical soap and water scrubbing of the operative site, followed by an antiseptic solution. The procedure should involve a ten-minute period, and should be performed at the time of the shaving of the operative site, and again in the operating room just prior to the skin incision.<sup>149</sup>

Draping. Draping the patient in surgery has received wide attention, with caution that sterile, double thickness linen should be applied and anchored accurately within the limits of the area prepared. Wound towels should be applied accurately to the edges of the incision to prevent bacteria from the deeper recesses and glands of the skin from coming to the surface and contaminating the wound.<sup>150</sup>

Surgical hand scrub. To minimize contamination of surgical wounds at the time of surgery, a careful, timed, and adequate scrub of the hands and entire forearm, with meticulous care of the fingernails, was recommended, with re-scrubbing between cases.<sup>151</sup> General in literature was the feeling that there should be a return to the ten-minute scrub practices before antibiotics were made available, based on the observation that the mechanical removal of dirt and debris from the skin by conscientious scrubbing cannot be replaced by a two to three minute scrub with an antiseptic soap. There are differences of opinion

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<sup>149</sup>Adams, loc. cit.

<sup>150</sup>Altemeier, "Symposium on Hospital Acquired Staphylococcal Infections, Part III. Recommendations for Control of Epidemic Spread of Staphylococcal Infections in Surgery," op. cit., p. 775.

<sup>151</sup>Ibid.

as to the effectiveness of bar soap versus liquid soap.<sup>152</sup>

Gloves. Best quality gloves should be used during surgery. If gloves are punctured or contaminated, they should be changed immediately and carefully. Studies have shown that rubber gloves become punctured in over half of the operations.<sup>153</sup>

It has been recommended that the process of powdering the hands should be done in an anteroom instead of the operating room, while the sterile gowning and gloving should be done in the operating room.<sup>154</sup>

Precautionary and cleaning measures. Aside from the meticulous housekeeping to be performed daily in the operating room, precautionary and cleaning measures should be performed between cases,<sup>155</sup> particularly when septic areas are encountered inadvertently, with wet mopping and wet surface cleaning minimizing air contamination.

For known infection cases requiring surgery, these conditions should be pointed out at the time of scheduling so that proper technique can be carried out to reduce danger to other patients and personnel, and to prevent general contamination of the entire operating suite.<sup>156</sup>

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<sup>152</sup>"A.M.A. Hears Report of Hospital Infections," op. cit., p. 51.

<sup>153</sup>Altemeier, loc. cit.

<sup>154</sup>Adams, op. cit., p. 346.

<sup>155</sup>Altemeier, op. cit., p. 776.

<sup>156</sup>Harder, loc. cit.



It has been found advisable to schedule at the end of the operating day those patients with known infections who require operating room procedures,<sup>157</sup> with thorough cleaning of the room and equipment with a disinfectant after the procedure.

### Handwashing

General handwashing throughout the hospital, if properly carried out, was considered possibly the most consistent defense against the spread of infection among people. The hands should be washed before and after caring for any patient in isolation or on general care, and at intervals during the care of a single patient if indicated to control the spread of organisms. Foot, knee, or elbow controlled fixtures for water and soap should be conveniently provided to encourage the important handwashing procedure.<sup>158,159</sup> The provision of antibacterial soap for general use in hospitals is becoming more frequent.

### Sterilization

An area of true sterility may be considered to be adequately packaged and sterilized goods. However, these may also be contaminated through poor technique in their handling, and through faulty sterilization. Test methods of sterilization should be evaluated, with routine check on bacteriological and thermal effectiveness of sterilization

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<sup>157</sup>"A.M.A. Hears Report of Hospital Infections," loc. cit.

<sup>158</sup>M. E. Benson, "Handwashing--An Important Part of Medical Asepsis," American Journal of Nursing, 75:1136-1137, September, 1957.

<sup>159</sup>Brown, op. cit., p. 1188.

procedures, Proper packaging, arranging of load, drying, handling, and storage of supplies should be worked out. It has been emphasized that an object is either sterile or contaminated, and that contaminated supplies may lead to infection.<sup>160</sup>

#### Interruption of Normal External Physiological Barriers

Procedures which interrupt the normal external physiological barriers favor the spread of bacteria. Recommendation was made that such procedures be kept at a "practical minimum consistent with good surgical care." Specifically mentioned procedures were prolonged intravenous therapy with indwelling venous needles or catheters, spinal taps, intracardiac diagnostic procedures, thoracenteses, paracenteses, and bladder catheterizations.<sup>161</sup>

#### Excreta

Aside from proper handwashing techniques, Benson suggested that when caring for a patient involves a massive exposure of hands and fingernails to pathogens in profuse drainage, or excreta from seriously ill incontinent patients, gloves should be worn.<sup>162</sup> Brown recommended for the infection prevention program, that bedside equipment be washed daily.<sup>163</sup>

According to Adams, we must admit failure in finding a solution

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<sup>160</sup>Beck, op. cit., p. 140.

<sup>161</sup>Altemeier, op. cit., p. 775.

<sup>162</sup>Benson, op. cit., p. 1137.

<sup>163</sup>Brown, loc. cit.



to the problem of infection from bladder catheterization. He felt that the greatest improvement has come from changes in routine which have reduced the number of necessary catheterizations in post-surgical patients. He listed the main advantages as insuring adequate hydration during and immediately after anesthesia to force an early need to void, minimal dosage of narcotics which depress the micturation reflex, and early awakening of the patient. If a patient requires bladder catheterization, the procedure should be "treated with the seriousness accorded a minor operation, and a preliminary preparation carried out which is similar to that of skin preparation for a surgical incision."<sup>164</sup>

Ansell's suggestions to avoid infection in patients requiring an indwelling catheter were: the use of the smallest catheter to do the job, aseptically and atraumatically placed; a closed system of irrigation and drainage, with antiseptic in the collecting bottle to prevent growth of any possible contaminant; continuous egress of urine; and high fluid intake.<sup>165</sup> Ascending infections are unavoidable when tubing is above the level of the bladder, or if its length causes stasis of urine.<sup>166</sup>

#### Wound Dressing Procedures

Wound dressing procedures have been investigated in detail in an attempt to reduce infections. Suggestion was made for the adoption of

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<sup>164</sup>Adams, op. cit., p. 347.

<sup>165</sup>J. Ansell, "Some Observations on Catheter Care," Journal of Chronic Diseases, 15:678, July, 1962.

<sup>166</sup>Santora, op. cit., p. 794.

a two-man dressing technique, with an intermediate tray, to keep the individual doing the dressing away from the dressing cart. Suggestion was also made to keep the cart away from the patient's bed. The general dressing cart should not enter isolation areas. There should be careful washing of hands by the doctor and his assistant before and after dressing changes, and the use of gloves and masks during changes was encouraged. All soiled dressings should be placed in a closed bag to be burned, and infected dressings should be well marked for processing. For infected cases, it was reported that there are those who place all instruments, dressings and infected materials in bags and sterilize them before further handling and cleaning. Appearing more frequently is the conviction that to prevent contamination and spread of infection, dressing carts and trays should always be accompanied by a graduate nurse well trained in sterile technique.<sup>167,168,169</sup>

The Surveillance Committee of the University of Texas Medical Branch recommended that whenever possible a treatment room should be used for dressing changes. The committee also felt that dressing carriages and their equipment should be cleaned weekly and whenever there is question of contamination in any degree.<sup>170</sup>

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<sup>167</sup>"Medical Authorities Recommend Ways to Curb Infections," loc. cit.

<sup>168</sup>Altemeier, op. cit., p. 776.

<sup>169</sup>"A.M.A. Hears Report of Hospital Infections," op. cit., p. 50.

<sup>170</sup>Staphylococcal Disease, op. cit., p. 25.



## Isolation

In discussing control of hospital infections, the great majority of writers stressed the dire need for the introduction of adequate and realistic pre-antibiotic-era isolation techniques for the segregation of active and virulent infections. The ideal plan for segregation of infected patients was given as a separate unit away from the clean surgical patients, cared for by separate personnel.<sup>171</sup> It has been recommended that as soon as there are clinical grounds to suspect wound infection, the patient should be isolated to prevent spread.<sup>172</sup>

There was unanimous agreement that contaminated linen, dressings, and waste in the operating room and on the units should be separated, sealed, and marked for special treatment. Recommendation has also been made that contaminated instruments, linens, blankets, and gloves be sterilized before sorting, cleaning, and re-sterilizing.<sup>173</sup>

Paper service should be utilized for meals served to infected or suspected patients, and refuse placed in waterproof bags for burning. Nondisposable items should be disinfected before their return to the kitchen.<sup>174</sup>

The room and furnishings that have been used by an infected patient should be thoroughly cleaned with antiseptic solution<sup>175</sup> before

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<sup>171</sup>Harder, op. cit., p. 351.

<sup>172</sup>"Medical Authorities Recommend Ways to Curb Infections," loc. cit.

<sup>173</sup>Altemeier, op. cit., p. 777.

<sup>174</sup>Staphylococcal Disease, loc. cit.

<sup>175</sup>Ibid.

another patient is allowed to occupy the area.

Of growing interest has been the isolation for their protection of some patients who are especially susceptible to staphylococcal infections. Dr. Charles Beal, Assistant Professor of Preventive Medicine at Stanford University School of Medicine, has recently developed a plastic room, which looks like a transparent tent, for the isolation of patients who are highly susceptible to germs.

It engulfs the patient and the bed, eliminating the need for sterilization of persons and objects entering the room. Shots can be given and blood drawn by inserting a needle through the plastic. Arm vents with rubber gloves are attached at intervals to the plastic tent to allow for patient care. The unit, which can be discarded after use, has a self containing air supply. Air pressure on the inside is slightly higher than on the outside so that no bacteria can enter.<sup>176</sup>

### Ventilation

Air is the "common medium which exposes patients to almost all segments of the total environment." As an elementary but essential precaution, Kethley stated that clean air only should be introduced into the hospital. The location of inlets bringing air into the hospital should always be located at as great an elevation as possible, never downward from a pollution source, nor adjacent to the operating room exhaust. He felt that low efficiency filters would usually pay for themselves by reducing the dirt load of the hospital environment, and would contain not more than one bacterial particle per cubic foot, and usually less.<sup>177</sup>

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<sup>176</sup>The San Bernardino Daily Sun, June 15, 1964, p. A-4.

<sup>177</sup>Institutionally Acquired Infections, op. cit., pp. 39, 44.



Frequent changes of filters for incoming air, and proper cleaning and maintenance of systems now in operation for removal of dust, bacteria, and powder from the air, have been recommended.<sup>178</sup> Correction should be made of systems which pull air from public corridors or wards into the operating room.

Suggestion has been made that for the operating room, there should be investigation of the possibility of installing floor exhaust outlets and a ventilating system that would give fresh outside air changes at a rate of eight to twelve changes per hour, with exhausts removing only from two-thirds to three-fourths of air so positive pressure would remove dust out through leaks or open doors.<sup>179</sup> In discussing highly filtered air at ten to twenty changes per hour, Bourdillion suggested that "hospitals should satisfy themselves about the purity of the air in their operating theatres and dressing stations just as they do their water and milk supplies."<sup>180</sup>

### Laundry

The handling of laundry, especially contaminated linen, has been stated to be an important factor in infection control. Among considerations for prevention should be a place to sort linen away from extractors and freshly laundered linen. Personnel handling contaminated linen

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<sup>178</sup>Altemeier, op. cit., p. 778.

<sup>179</sup>"Medical Authorities Recommend Ways to Curb Infections," loc. cit.

<sup>180</sup>Environmental Aspects of Staphylococcal Disease, op. cit., p. 91.

should wear masks, gowns, and gloves for their own protection. Pathogenic agents should be removed in the washing process. Freshly laundered linen should be transported in clean, covered containers, and stored adequately until used.<sup>181</sup>

Studies have been done to re-evaluate laundry procedures, construction, and ventilation control with the knowledge that a good laundry process for removing bacteria and other pathogenic agents becomes of little importance if the environment in which linen is carried and stored merely re-contaminates it with the same organisms.<sup>182</sup>

#### Housekeeping

The cleaning of the hospital environment, according to Brown, means not only the removal of dust and dirt, but the use of methods to eliminate or reduce airborne staphylococcal organisms by concurrent and terminal disinfection, sunlight, proper ventilation, and adequate cleaning supplies.<sup>183</sup>

A disinfectant to scrub the floors throughout the hospital, not only in the operating rooms and communicable disease areas, was highly recommended. Wet mopping was recommended, with frequent change of mop heads and scrub water, and always a change of both after scrubbing a contaminated area. Other suggestions were treated dust mops instead of dry push brooms, and routine moist dusting with attention to overhead

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<sup>181</sup>Harder, loc. cit.

<sup>182</sup>B. D. Church, "The Role of the Laundry in the Recontamination of Washed Bedding," Journal of Infectious Diseases, 93:74, July-August, 1953.

<sup>183</sup>Brown, op. cit., pp. 1189-1190.



lights, window sills, ledges, pipes, doors, radiators, furniture, and any area where dust can accumulate and liberate into the air. Attention should also be given to clean mattress and pillow covers, and curtains between patients and whenever soiled.

Brown stated that the use of a vacuum cleaner in hospitals is not recommended because both the bag type and water filter type disseminate the organisms they pick up, and a filter fine enough to prevent bacteria from passing through the vacuum cleaner probably would be an inefficient cleaner.<sup>184</sup>

Suggestion was also made that in order to avoid emptying waste receptacles and liberating bacteria into the air, that either disposable waste receptacles be used,<sup>185</sup> or that waterproof bags line the waste containers so they might be sealed and removed without the contents being disturbed. It was also felt advisable that waste disposal receptacles be put under a definite cleaning schedule, procedure to be determined by the nature of the waste.<sup>186</sup>

It was considered important to arrange general cleaning at times when dressing changes were not being done.<sup>187</sup>

Artz reported in a study of 3,759 cultures, that "despite superb housekeeping procedures," 32 percent of the cultures taken from food

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<sup>184</sup>Ibid., p. 1190.

<sup>185</sup>Environmental Aspects of Staphylococcal Disease, op. cit., p. 53.

<sup>186</sup>Staphylococcal Disease, loc. cit.

<sup>187</sup>Harder, loc. cit.

tables, 20 percent from trash cans, wash areas, bedside tables, and dressing carts, were positive for S. aureus.<sup>188</sup> Such a report justifiably may cause one to speculate just what the environmental situation might be minus careful housekeeping procedures.

There are differences of opinion in literature as to the importance of personnel versus environment in the spread of infections. Goddard stated, however, that environmental controls should be utilized to the fullest because asepsis has resulted in dramatic improvement in hospital infection, because many outbreaks have resulted in relaxation of environmental control, and on the basis that "the more snakes there are in the grass, the greater is the chance of getting bit."<sup>189</sup>

#### Rules Governing Patients and Visitors

The following rules governing patients and visitors at the University of Texas Medical Branch were designed to assist in the control of infectious diseases:

1. Patients are to remain in assigned areas. A patient must not leave a ward area without permission of the nurse in charge and shall not enter another ward area.
2. Patients may not trade or loan personal property.
3. Any patient assisting in the care of another patient shall do so only with the approval of the nursing staff. Such patients shall wash their hands before and after giving such services.
4. On admission, all patients will, unless there are contraindications, be bathed.

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<sup>188</sup>Artz, op. cit., p. 583.

<sup>189</sup>Institutionally Acquired Infections, op. cit., p. 4.



5. All parents or other visitors will assist in the care of patients only with the approval of the nursing staff. Such individuals must be instructed in hand washing and other pertinent ward techniques. These techniques must be followed.
6. Personnel must not visit in a unit other than their assigned unit.<sup>190</sup>

### Antibiotics

Writers mentioning antibiotics in relation to hospital infections stress the fact that prophylaxis with antibiotics in almost all instances should be discontinued. The use of antibiotics prophylactically imparts a false sense of security, and has not and will not substitute for established surgical principles or techniques.<sup>191,192,193</sup>

According to Fekety, antibiotics do not cause hospital infections; yet they are important determinants of the kinds of organisms to be found in hospitals. He stated that the incidence of antibiotic-resistant infection, and the number of disseminators of resistant staphylococci, should be reduced

. . . if antibiotics are not used when they are not needed, if they are not used prophylactically when this is unjustified, if they are not used in combinations when one agent will suffice, and if they are used in doses as small as is consistent with good medicine.<sup>194</sup>

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<sup>190</sup>Staphylococcal Disease, loc. cit.

<sup>191</sup>"Medical Authorities Recommend Ways to Curb Infections," loc. cit.

<sup>192</sup>"AHA's Recommendations on Prevention and Control of Staphylococcus Infections in Hospitals," loc. cit.

<sup>193</sup>Altemeier, op. cit., p. 777.

<sup>194</sup>F. R. Fekety, Jr., "The Epidemiology and Prevention of Staphylococcal Infection," Medicine, 43:596-597, 1964.

### When "Hospital Staph" Goes Home

Considered in the control of infections was the patient who goes home from the hospital with a staphylococcal infection, often starting and perpetuating an epidemic of family staphylococcus. Cross infection in the household, with possible re-admission to the hospital of the infected patient, and/or a member of his family, may be avoided by simple precautions understood and carried out by the patient and his family.

The following precautions against spread in the household were suggested:

1. Dispose of used dressings promptly. Put them in a paper bag, close it immediately, and burn it at the first opportunity.
2. Wash hands after possible contamination (changing a dressing or other contact with an infected person or his clothing).
3. Use germicidal soap; better still substitute for the customary family cake of soap a dispenser of germicidal detergent. Several brands used widely are available in many pharmacies and department stores.
4. Give each family member his own towel and washcloth; use paper towels at the kitchen sink, never a community towel.
5. Take showers rather than tub baths when possible.
6. Keep toilet seat, bathtub, shower stall and other bathroom appurtenances scrupulously clean. Disposable paper toilet seat covers are recommended.
7. Change bed linen daily if it is subject to contamination.
8. Boil bed linen and towels of infected persons. All other items should be laundered at the highest temperature that will not damage the materials concerned, using a bleach if possible. After tumbling in a home dryer or drying in bright sunshine, iron each piece, preferably with a dry rather than a steam iron.
9. Isolate infected family members as much as is practicable.<sup>195</sup>

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<sup>195</sup>"Staphylogistics at the Family Level," Spectrum, September-October, 1963, p. 71.



After a review of literature on prevention and control of staphylococcal infections in hospitals, one must agree with Burnett that "there is no one source of error, but many small facets which must be corrected and vigilantly policed."<sup>196</sup>

#### IV. SUMMARY

Postoperative wound infection is considered to be a major surgical problem. The rate of surgical wound infection on a well regulated surgical service has been given as between one and two percent. Most reports reviewed, however, have shown that surgical wound infection rates exceeded this amount.

Increased interruption of the normal external physiological barriers, and decreased resistance of the host by disease and drug or treatment-produced complications are contributing factors to the problems of staphylococcal infection. The indiscriminate use of antibiotics has added to the seriousness of the problem by producing virulent, antibiotic-resistant strains of staphylococci in both patients and personnel, and by encouraging laxity in practicing successful measures for the treatment and prevention of infection.

Staphylococci may be transmitted by both direct and indirect contact. Contaminated air may spread infection through ventilating and air conditioning systems, by drafts from laundry and trash chutes, and by routine activities of both patients and personnel. Personal contact

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<sup>196</sup>W. E. Burnett, "Program for the Prevention and Eradication of Staphylococcic Infections," Journal of the American Medical Association, 166:1183, March 8, 1958.

is considered to be the most common method of disseminating organisms throughout the hospital. Although the nose and throat are believed to be the chief reservoirs of virulent staphylococci, the individual with an active lesion is considered to be the most dangerous.

Solution to the problem at present appears to be an awareness that a problem exists, services for identifying and tracing origins of infection, an organized and supervised return to the successful pre-antibiotic-era aseptic techniques throughout the hospital which have fallen into disuse through false security, and restriction of the prophylactic use of antibiotics.

General handwashing throughout the hospital is considered to be possibly the most consistent defense against the spread of infection among people.



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## APPENDIX



## APPENDIX A

TOOL FOR GATHERING DATA FOR THE INVESTIGATION OF ADDITIONAL  
HOSPITAL EXPENSES REQUIRED AS A RESULT OF STAPHYLOCOCCAL  
INFECTION IN CLEAN SURGICAL WOUNDS

Code No. \_\_\_\_\_ Sex \_\_\_\_\_ Age \_\_\_\_\_ Race \_\_\_\_\_

Admission Date \_\_\_\_\_ Discharge Date \_\_\_\_\_

Surgery Date \_\_\_\_\_ Operation \_\_\_\_\_

OR and Rec. Rm. Chgs.	Laboratory Chgs.	X-ray Chgs.	Pharmacy Chgs.	Central Supply Chgs.
Room Chgs.	Miscellaneous Chgs.	Total Chgs.	Date and Report of Wound Culture	Remarks

APPENDIX B

CHECK LIST FOR REPORT OF PHYSICAL CHARACTERISTICS  
OF PATIENTS WITH STAPHYLOCOCCAL INFECTIONS

Code No. \_\_\_\_\_ Sex \_\_\_\_\_ Age \_\_\_\_\_ Race \_\_\_\_\_

Admission Date \_\_\_\_\_ Discharge Date \_\_\_\_\_

Description of Infection:

Surgical Procedures:

Wound Cultures:

Physical History:



LOMA LINDA UNIVERSITY

Graduate School

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TWO ATTEMPTED INVESTIGATIONS INTO THE COMPLEXITIES  
OF STAPHYLOCOCCAL DISEASE

by

Harriet M. Sands

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An Abstract of a Thesis  
in Partial Fulfillment of the Requirements  
for the Degree  
Master of Science in the Field of Nursing

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June 1966

## ABSTRACT

Two investigations were attempted to add insight into the multiple problems related to staphylococcal infections. A comparison study was made of the hospital expenses of a group of hospitalized patients whose apparently clean surgical wounds developed staphylococci, and a comparable group whose surgical wounds healed without infection.

A review of approximately one hundred medical records for the pilot study revealed three instances of staphylococcal infection in apparently clean surgical wounds. The three patients required 239 days of hospitalization at a total hospital cost of \$13,702.11. The three comparable patients whose surgical wounds remained clean required 27 days hospitalization at a total hospital cost of \$1,283.21. However, only one case of infection in a surgical wound was found during a review of ninety-eight charts which was the criteria in the selected hospital for the two-year period 1962-1963.

It was felt that a report of selected physical characteristics of this same group of ninety-eight patients would give nurses additional insight into the admission and treatment of patients with staphylococci by indicating some types of patients who may be the means of disseminating staphylococci within the hospital, and by identifying highly susceptible patients who need protection from infection.

A total of 280 constitutional problems were found among the ninety-eight patients, ranging from zero to 10 in each patient, and making an average of 2.86 for each patient. In addition, three patients had received radiation, and six had received steroid therapy.



One hundred fifty-eight infections and inflammations which included chronic, recurrent, recent, or current processes that might conceivably contribute to the development of staphylococcal wound infection either directly or indirectly were identified. Respiratory infections was the largest single classification with 38 cases. One hundred twenty-two other physical problems were found among the patients.

The findings of respiratory, skin, urinary, and gastrointestinal infections and inflammations on a chronic, recurrent, recent, or current basis, coupled with actively draining osteomyelitis and other oozing sinuses and skin inflammations, point to patients who may be the means of disseminating staphylococci within the hospital. The reports of other constitutional problems affecting the infected patients indicate the highly susceptible patients who should be protected from infection.

Nineteen bacteria other than staphylococci, and fungus in two instances, were identified from wound exudate in the ninety-eight patients.